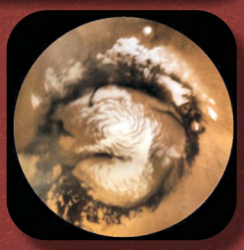
SAC Annual Report



वार्षिक रिपोर्ट

2015 ANNUAL REPORT 2016

अंतरिक्ष उपयोग केंद्र

Space Applications Centre

Indian Space Research Organisation, Ahmedabad-380 015.

Preface

Today space technologies are conquering new horizon in India with the realization of astronomical missions, diversified use of space technologies and successful launch of satellites. Our space programme was envisaged by Dr. Vikram Sarabhai with a vision to use space technologies for the benefit of common man. SAC is actively corresponding to this vision through payload development and various space based applications for the society. All our payloads are functioning brilliantly and our applications' are reaching to the remote parts of the country. An attempt is made to take readers to the heart of our activities through this annual report.

This year some of the marvelous and exciting communication and navigation payloads for GSAT-15, GSAT-6, GSAT-18, INSAT-3DR and IRNSS-1E, IRNSS-1F & IRNSS-1G are delivered. The In Orbit Testing (IOT) and commissioning of communication payloads for GSAT-15, GSAT-6 and IRNSS-1E, IRNSS-1F & IRNSS-1G were successfully completed. Development of various Subsystems for GSAT-17, GSAT-9, GSAT-11, GSAT-19, AIS, IRNSS-1H, IRNSS-1G, GSAT-7A, GSAT-20& GISAT-1 & 2 are in progress.

Advanced MSS satellite (GSAT Series) is one of significant contribution for the service of nation. The Field trial of all four types of Mobile Satellite services, Like Multimedia service, broadcast service, reporting service and Voice service were demonstrated with in-house developed terminals. These versatile MSS terminals were also demonstrated to Hon. Prime Minister.

It is also a landmark year for Optical EO payload fraternity. SAC has delivered one of the finest optical payload for Cartosat-2C with highest resolution till date in ISRO history and also delivered LISS-3 payload for Resourcesat 2A. Payload development works for Scatsat-1, GISAT-1, GISAT-2, Chandrayan-2, RISAT-1A, NISAR, Oceansat-3, RISAT -2A, INSAT-3DS, MicroSat and Hyper Spectral Imaging Satellite are progressing at various stages. Towards planetary missions, MOM has Generated new Mars Mosaic using MCC datasets and Chandryaan-1 Announcement of Opportunity (AO) meet was conducted.

During this year some of the advanced R&D programme were initiated in the Centre namely Development of Terahertz Sub-Mm Wave & IR Sensors/ Telescope, Ground-based Standalone Pseudolite Navigation System Infrared Spectrometer Development and ASIC development for IRNSS receiver.

SAC has made very distinctive contribution in the field of agriculture, forestry, coastal zone management, fisheries, urban planning, watershed development, ground water prospecting, snow & glacier studies, oceanography and atmospheric studies through its remote sensing applications.

Satellite based nowcasting method for heavy rainfall alerts over India has been developed and is operational through MOSDAC web portal since onset of monsoon-2015. Science Products on Sea Ice Occurrence Probability, Sea Ice Advisories for the Indian Scientific Expedition, Inland Water height, Heavy Rain and Dust Storm events are also released on MOSDAC. Four bulletins of agricultural outlook of India from space are prepared from INSAT 3A and disseminated through MOSDAC during the year.

In order to strengthen the dissemination of data "Visualization of Earth Data and Archival System" (VEDAS) was initiated which provided a platform, infrastructure and guidance for utilisation of information derived over land to develop custom crafted geo-spatial applications, that will provide a newer and innovative way for the applications development.

It is expected that with such a handshake between data generators and potential analysts, newer and innovative ways will emerge as a game changer for the Applications' development.

Desertification Status Mapping on 1:500,000 scale using AWiFS for 29 states and the Union Territory of Andaman & Nicobar was completed. SAC has published and released Desertification and Land Degradation Atlas of India. In addition to this Geo spatial database with AWiFS images and beta version of soil wetness index map is also made available.

INSAT-3D has completed two successful years in-orbit in July 2015. INSAT-3D Imager and Sounder data processing and the products are routinely generated at MOSDAC and IMDPS at India Met Department. The third version of the Ground Penetration Radar (GPR) was calibrated and applied at Antarctica for Snow and Ice studies as part of the 35th ISEA.

About 28 MOUs and 3 technology transfer agreements are signed during the year. 94 technology development projects and 47 respond programmes are going on at the centre.

Various lectures were conducted under SAC Knowledge lecture series for the benefits of SAC & DECU employees. Moreover, SAC Library premise was made Wi-Fi enabled for smoother access to e-resources. Centre has actively participated in national events like Digital India Week and in Make in India Week. A workflow based online system -"Anubhav" software for superannuating employees was developed and launched for the entire SAC community.

During the year various facilities are established as well as augmented at the centre to facilitate payload development activities. VSSE exhibition is receiving tremendous footfall and mobile exhibitions at various places are being well received.

In order to maintain the unique ecosystem of SAC, we initiated tree plantation across the campus and approximately 350 trees have been planted by various personnel of SAC and DECU. CMG, Administration, Accounts and Purchase have aptly supported the activities of the Centre throughout the year.

I am sure that SAC will continue to achieve yet other significant milestones in coming years.

Tapan Misra

SAC Management Council (SMC)
As on March 31, 2016

- **Shri Tapan Misra, Director, SAC & Chairman, SMC**
- **Shri Virender Kumar, Director, DECU**
- **Shri R. K. Arora, Controller, SAC/ DD, ESSA**
- **Shri D. K. Das, DD, SNPA**
- **Dr. B. S. Gohil, DD, EPSA**
- **Shri R. M. Parmar, DD, SEDA**
- **Shri Nilesh Desai, DD, MRSA**
- **Shri K. S. Parikh, DD, SNAA**
- **Shri H. R. Kansara, DD, MESA**
- **Shri Rajiv Jyoti, GD, ASG**
- **Shri Debajyoti Dhar, GD, SIPG**
- **Shri A. K. Lal, GD, SRG**
- **Shri Vikas Patel, GH, PPG & Member Secretary, SMC**

Republic Day celebration at SAC

SAC ORGANIZATION
As on March 31, 2016

Tapan Misra
Director

R. K. Arora Controller & Deputy Director, ESSA	**R. M. Parmar** Deputy Director, SEDA
N. M. Desai Deputy Director, MRSA	**K. S. Parikh** Deputy Director, SNAA
Vikas Patel Group Head, PPG	**A. K. Lal** Group Director, SRG
D. K. Das Deputy Director, SNPA	**Rajeev Jyoti** Group Director, ASG
B. S. Gohil Deputy Director, EPSA	**Debajyoti Dhar** Group Director, SIPG
H. R. Kansara Deputy Director, MESA	**Sivanandan G** Internal Financial Advisor

Tree Plantation at SAC

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Ruby celebration of SITE at SAC

SPACE APPLICATIONS CENTRE

SAC

Space Applications Centre (SAC) is a unique centre dealing with a wide variety of themes from payload developments to societal applications & thereby creating a synergy of technology, science and societal applications. The centre is responsible for the development, realization and qualification of Communication, Navigation, Earth observation and Planetary payloads and ground systems related data processing in the areas of communications, broadcasting, remote sensing, disaster monitoring/mitigation, etc. It is playing an important role in harnessing space technologies for a wide variety of applications for societal benefits. In order to carry out the above tasks, SAC has highly sophisticated payload integration laboratories, electronic and mechanical fabrication facilities, environmental test facilities, systems reliability/assurance group, image processing and analysis facilities, project management support group and a well-stocked library. SAC has also put adequate emphasis on and practicing outsourcing and indigenous development of technology and vendors.

Activities at SAC are organized into following Areas:

- SATCOM and Navigation Payload Area (SNPA)
- SATCOM and Navigation Applications Area (SNAA)
- Sensor Development Area (SEDA)
- Microwave Remote Sensors Area (MRSA)
- Earth, Ocean, Atmosphere, Planetary Sciences and Applications Area (EPSA)
- Electronic Support Service Area (ESSA)
- Mechanical Engineering Systems Area (MESA)
- Planning and Projects Group (PPG)
- Signal and Image Processing Group (SIPG)
- Systems Reliability Group (SRG)
- Antenna Systems Group (ASG)
- Library
- Administration & Auxiliary services

Flag-off function of INSAT-3DR Payload

SATCOM & SATNAV

Payload Developments

SAC is major centre of ISRO responsible for designing the communication payloads. The centre is also involved in development of subsystems, integration and testing the payloads for GEOSAT & IRNSS programs.

Payloads for GSAT-15, GSAT-6, GSAT-18, INSAT-3DR and IRNSS-1E, IRNSS-1F& IRNSS-1G were delivered to their projects in 2015-16. The In Orbit Testing (IOT) and commissioning of communication payloads for GSAT-15, GSAT-6 and IRNSS-1E, IRNSS-1F & IRNSS-1G were successfully completed.

Development of various Subsystems for GSAT-17, GSAT-9, GSAT-11, GSAT-19, AIS, IRNSS-1H, IRNSS-1G, GSAT-7A, GSAT-20 & GISAT-1 & 2 are in progress.

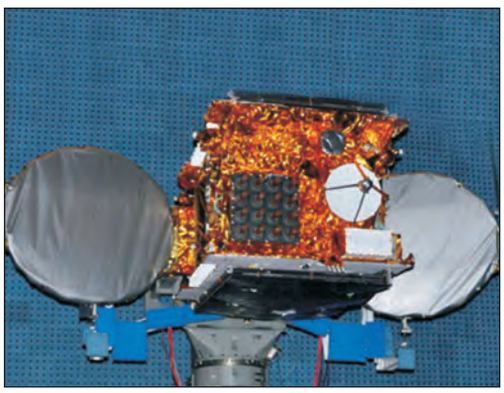
GSAT-15

GSAT-15 is a communication satellite operating from Georbital location. It consists of 24 Ku-band transponders, 2 GAGAN transponders and 2 Ku-Band beacons. Ku-band transponders are configured to provide DTH and VSAT services.

Design and development of GSAT-15 antennas was completed successfully and integrated with spacecraft. GSAT-15 satellite was launched in November 2015 from Kourou. In orbit testing of all transponders was successfully completed and payload performance was found to be satisfactory.

GSAT – 15 payload integrated with satellite

GSAT-15 pre-launch tests at Kourou



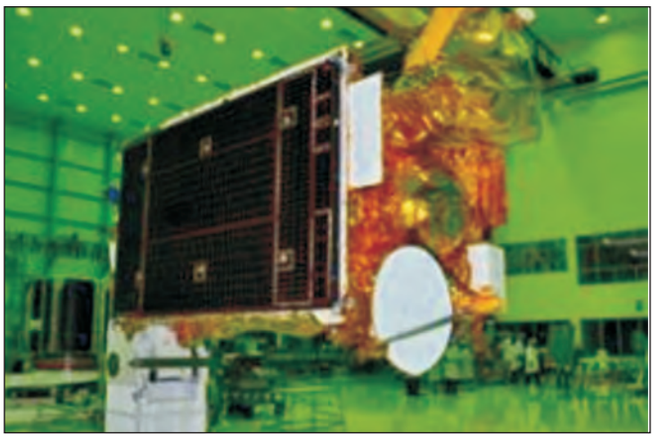
GSAT-15 Spacecraft under Test @ CATF

Advanced MSS Satellite

Advanced MSS Satellite is a S-band multibeam geostationary satellite, operating from geo slot of 83 deg E aimed to provide multimedia mobile services. The spacecraft is configured to provide one SxC and five CxS transponders.

The satellite were launched from SDSC SHAR, Sriharikota on August 27, 2015. In-orbit tests for SXC and CXS payloads completed from MCF-Hassan. Stability test of North beam was carried out from AES-Ahmedabad. Payload performance was found satisfactory.

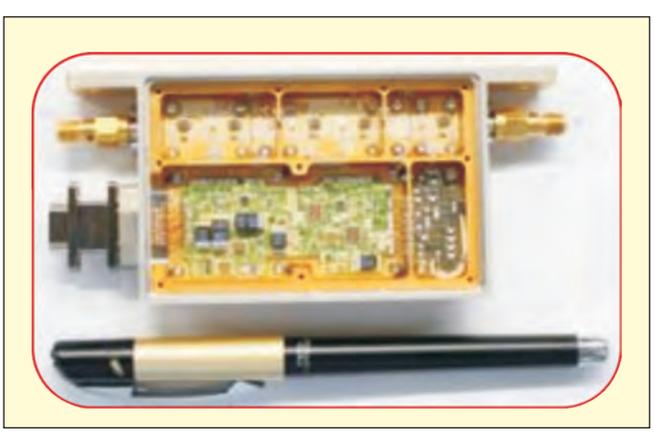
GSAT-6 satellite pre-launch tests at SHAR



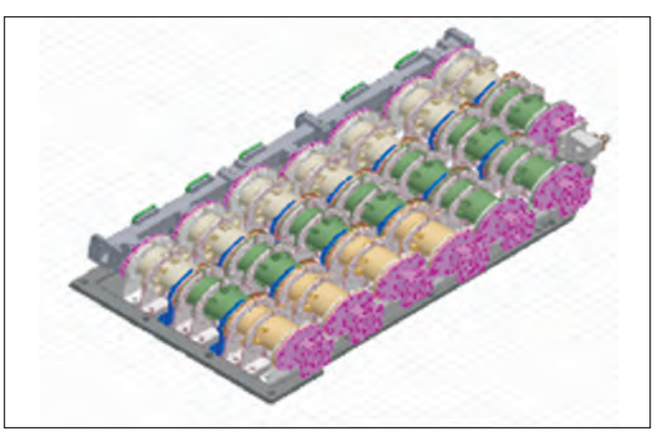
GSAT-6 satellite at clean room ISITE

GSAT-9 (SAARCSAT)

GSAT-9 is a Ku-band satellite configured to provide communication services over SAARC countries. It consists of 12 high power Ku-band transponders. The payload configuration was modified for the revised spectrum allocation of 13.00 – 13.25 GHz/11.20- 11.45 GHz. GSAT-9 has 12 Ku-band channels providing services for VSAT/DTH with South Asia coverage. It also has a Ku beacon transmitter with 480E/97.3E



SAC MMIC Ku ALC CAMP



Mechanical model of Ku 7 channel OMUX

GSAT-11

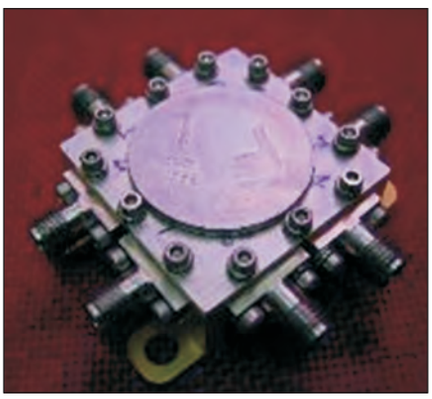
GSAT-11 is a high throughput multibeam satellite based on I-4 K bus. It is configured to provide user links in Ku-band through 32 spot beams and Hub link in Ka-band through 8 spot beams. It consists of 32 Ka x Ku transponders, 8 Ku x Ka Transponders.

Test and evaluation is completed for 12 units of Ka band TX/RX diplexer and Ext-C Band IMUX. In the Ku band Multibeam antenna subsystem, all the 16 FM OMTS were developed and successfully tested for high power margins. The Multimode horns, OMTS and tracking couplers were integrated with the respective feed clusters.

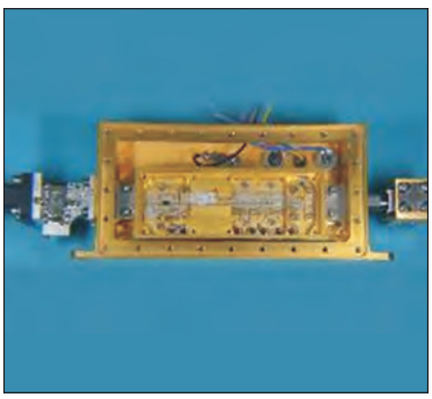
Open and closed loop tests (radiation mode in SAC CATF) of integrated QM tracking payload chain are completed successfully. Results are satisfactory.

FM development of LNAs, Frequency Sources and Frequency Converter are in progress. Design of PIN diode base SP4T switch is completed and DVM unit is developed. Indigenous Ku and Ka band SSPAs

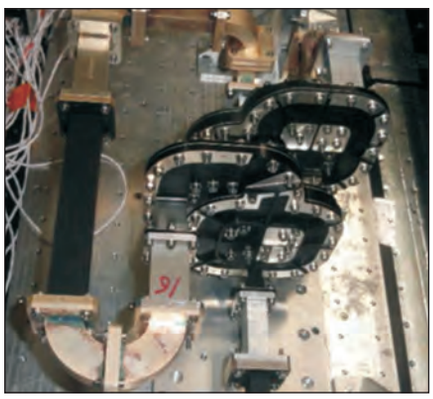
(QM +2 FM each) fabrication is in progress. Full characterization & optimization of total MPA on panel with actual hardware and DVM of Input hybrid network is done successfully. All cable lengths (Including redundant path) is optimised.



Input Hybrid Network of Ku-band MPA

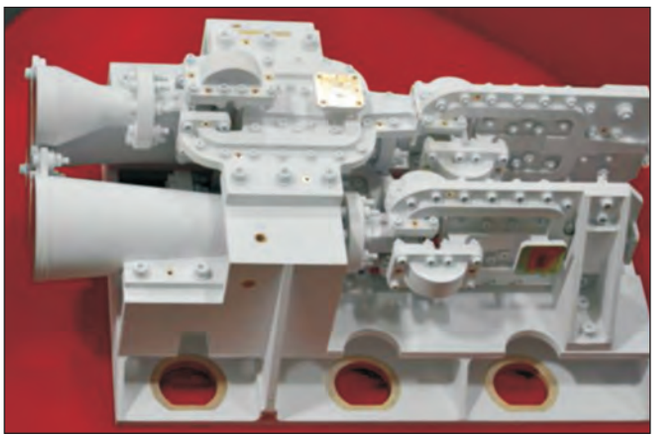


Ka Band LNA



Multipaction test of OMT

Flight Model of Ku-band SW Feed



Qualification Model of Ka-band Feed

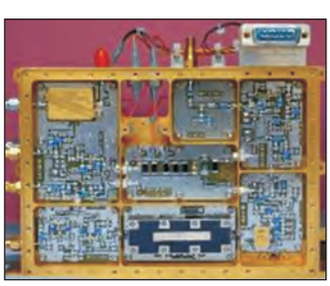
GSAT-7A

GSAT-7A is configured to provide communication capability to the users over Indian region in Ku-band. It provides three types of coverage beams: regional, wide and shaped India Beam. It consists of four nos. of 27 MHz and six nos. of 54 MHZ transponders.

Payload related details were finalized from the options considered earlier. All panel layouts were finalized and generated ILD for NORTH and SOUTH panels. Design of Payload subsystems is completed and hardware fabrication is in progress. Antenna development is in progress. High power 140W Ku-Band LTWTA procurement activity is in progress.

GSAT-17

GSAT-17 is a communication satellite configured to provide FSS in Normal C band Extended C bands, MSS in S-band and Data Relay and Search & Rescue services in UHF band. It consists of 24 Nor. C-band, 12 Upper Ext. C-band, 2 Lower Ext. C band, 1 DRT/SAR, 2 MSS forward and 1 MSS return transponders.



DRT Receiver

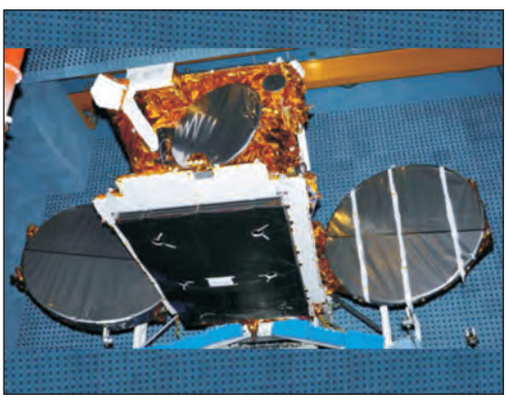
C-band Diplexers (DVM) are tested in TVAC condition for High Power

Handling test at 756 Watts CW power and Multipaction test at 20 kW peak power with 4 % Duty cycle. North panel & South panel ILDs are cleared. MIC fabrication of three C-band driver amplifier is completed. RF Optimization is under progress and compatibility of six units is completed. S-band Tx-Rx diplexer DVM testing is completed. RF Design of all the 7-antennas of the payload is completed successfully and are under various stages of realization.

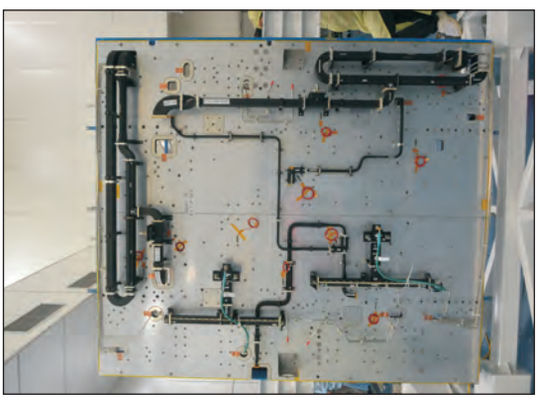
GSAT-18

GSAT-18 is a geostationary satellite having highest number of transponders among Indian Satellites. It consists of 24 No-C band, 12 upper Ext-C band and 12 Ku-band transponders along with 2 Ku-band beacons. It also consists of ISRO's first indigenously designed and developed Ku-band Tx-Rx DGR antenna with Rib-less Intercostal Structure.

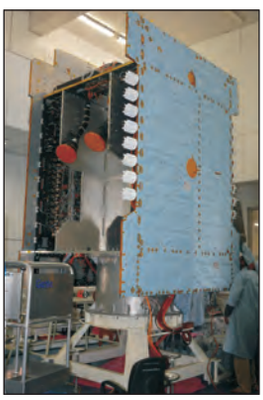
Integrated payload T&E for Nor-C band, Ext-C band, Ku band transponders and Ku-band beacon transmitters were completed successfully. The radiation test & payload level Thermo-vacuum test for C, Ext-C and Ku band payloads are completed successfully at SAC. This is the first Communication payload tested at Thermo-vacuum, SAC. Payload was flagged off from CSL, SAC to ISITE Bangalore on December 14, 2015.



GSAT-18 Antennas integrated with spacecraft



GSAT-18 EV Top Panel



GSAT-18 Integrated Payload

GSAT-19

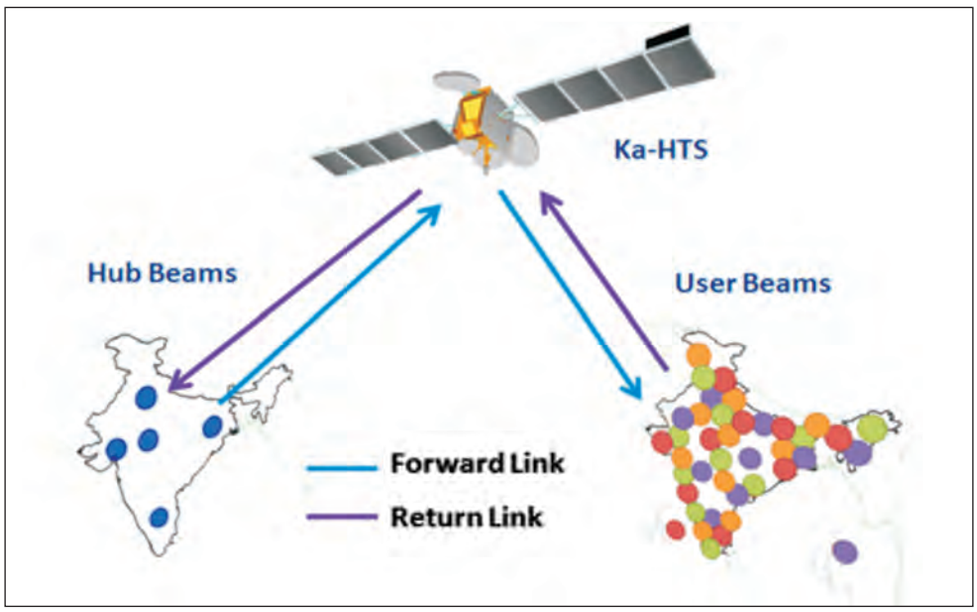
GSAT-19 is a Ku-band multi-beam satellite. It has Ka X Ku band multi beam payload with 8 Ku band user spot beams and 2 Ka band hub beams. It is a high throughput satellite based on I-3 K bus. The payload is configured to provide broadband services over major cities in Indian region. It is planned to be launched by first development flight of GSLV-Mk3-D1. Payload configuration along with subsystem specifications are finalized and circulated. RF design of antennas is completed.

GSAT-20

GSAT-20 is a Geo-mobile satellite for providing services to hand-held terminals over Indian region. Project report for payload configuration for GSAT-20 (S-band Mobile) is generated and submitted to GEOSAT program office.

GSAT-21

GSAT-21 is a Ka-band Multibeam satellite system having coverage over Indian Region with 40 spot beams. It will provide high throughput platform to large subscriber base for Broadband services. The payload is configured on I-3K bus. It consists of 30 Ka x Ka transponders and 2 Ka-band beacons. There are 5 hub locations. The payload is planned to be launched by second development flight of GSLV-Mk3-D2.



Ka-HTS System Architecture

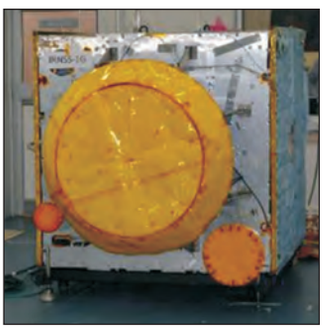
IRNSS (NAVIC)

Indian Regional Navigation Satellite (IRNSS) comprises of a constellation of seven satellites based on I-1k platform. IRNSS payload consists of L-band & S-band navigation payloads and C x C ranging transponders. The IRNSS system consists of 3 satellites in GEO orbit and 4 satellites in GSO orbit. It offers two services Standard Positioning Service (SPS) and Restricted Service (RS).

Payload level thermo-vacuum tests and radiation mode tests for navigation and ranging payload was completed at SAC and results are found to be satisfactory. After T&E payload was flagged off from SAC to ISITE Bangalore February 5, 2015, September 10, 2015 & February 5, 2016 respectively. Assembly of L5/S-Band Shared Aperture Helix Array Antenna was completed. Thermo vacuum cycling and Vibration test of the Shared Aperture Helical Array Antenna was completed.

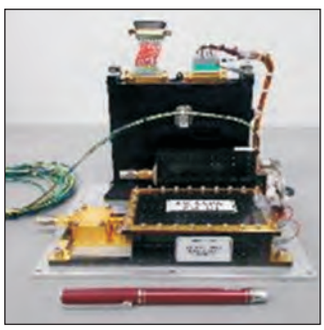
Presently, subsystem development of IRNSS-1H payload is in progress. Payload is expected to be delivered by November 2016. Four more units of 5-W C-band SSPAs made ready for IRNSS-1H & -1I through industry.

IRNSS-1E and IRNSS-1F were launched from SDSC SHAR, Sriharikota on 20th January 2016 and 10th March 2016. In-orbit tests (IOT) were completed and Payloads performance were found to be normal.

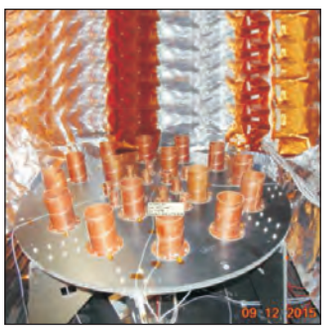


IRNSS-1G Radiation test at CSL, SAC

C-Band Receiver



5 Watt C-Band SSPA



Navigation Antenna and Ranging antennas

Automatic Identification System (AIS) Payload

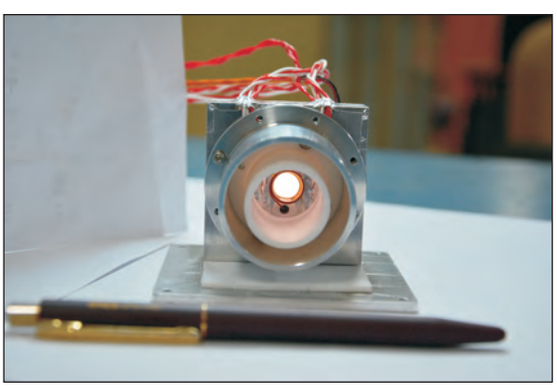
Automatic Identification System (AIS) is a Ship-to-Ship and Ship-to-Shore data broadcast system operating in the VHF maritime band. Ships broadcast information such as identity, position etc. to neighbouring ships and shore stations through AIS payload.

A hosted Payload configuration based on Store and Forward architecture has been finalized. Specifications for RF package, digital package and antennas are worked out and circulated. S-band and UHF antennas RF design of antennas for Automatic Identification System (AIS) payload at S and UHF bands are under progress.

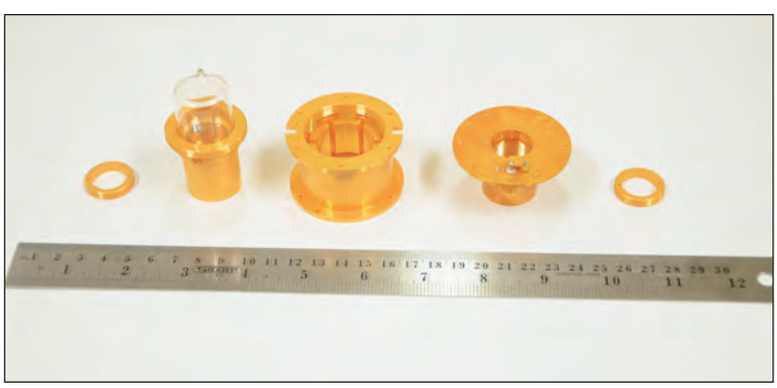
Development of Indigenous RB Clock

Atomic Clock payloads is the heart of the IRNSS satellite segment. Presently, state-of-the-art Rubidium Atomic Clocks are procured from SpTime/Airbus DS for the IRNSS project. With the vision of having indigenous atomic clocks onboard second generation IRNSS satellites exhibiting the stabilities of <5x10-12 □-1/2 at 1s and reaching the levels of <5x10-14 at 10,000 s, rubidium clocks are being developed at SAC.

Presently, at the SAC, the R&D of lamp-pumped Rb atomic clock is under progress, which involves novel schemes and techniques. This clock is named as Compact Indigenous Rubidium Atomic Clock (CIRAC). The entire design and development of CIRAC is an indigenous R&D of SAC, ISRO. Parallel to the R&D of CIRAC, the efforts are on to establish a state-of-the-art atomic clock laboratory for R&D of various indigenous atomic clocks, such as laser pumped Rb clock; trapped ion clock; passive H-Maser and portable optical clocks. This laboratory is planned at the new Bopal campus, Ahmedabad.



Fabricated Lamp package for CIRAC



In-house fabricated and gold plated magnetron cavity for CIRAC. Loaded cavity successfully tuned to 6.8GHz with a Q ~ 180

Design, Development, Qualification and Delivery of Ku Band Temperature Compensated Omux

Next generation of Ku-band OMUX technology – 7 channel contiguous high power Temperature Compensated Ku OMUX (TCKO) is designed, developed, qualified and successfully delivered for the first time for GSAT-18 communication payload. Use of this technology results in smaller footprint, light weight, higher power handling capability and superior RF performance as compared to existing Invar based Ku OMUX.

SATCOM & SATNAV

Applications

SAC is instrumental in design and development of different handheld and portable terminals with Unified IP based Hub to support different S-band communication services. Mobile Satellite Services-MSS in India has been of utmost importance for national disaster management and for strategic application needs.

Advanced MSS Satellite- Ground System

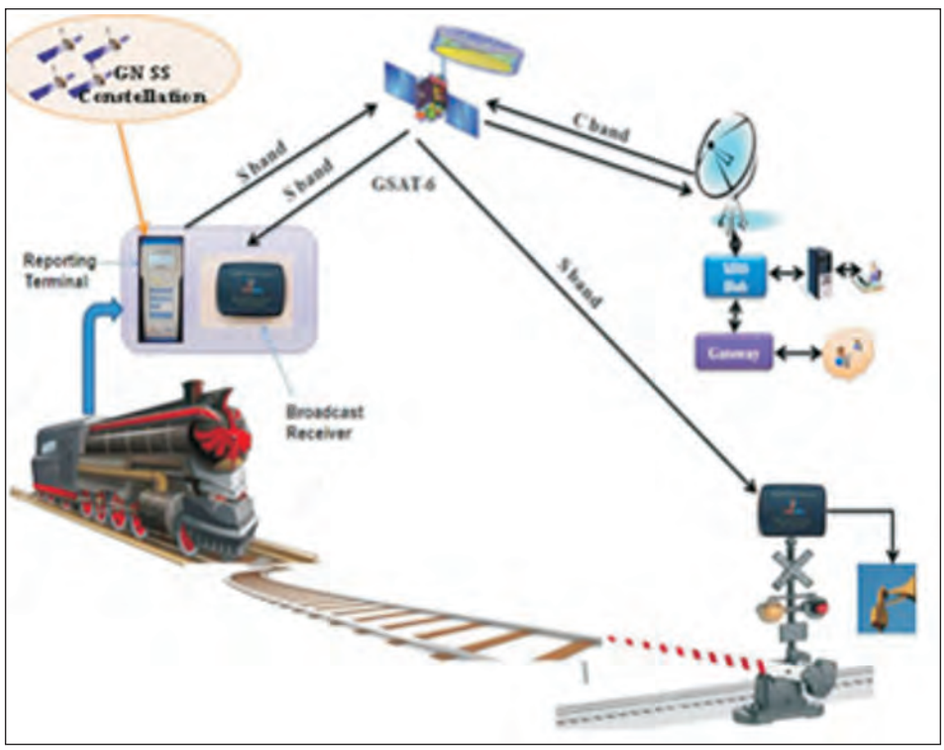
Antennas are developed for three different terminals of GAP-6 application project at S- MSS-band. All the three different types of antennas are successfully tested with GSAT-6 satellite. Four types of terminals, Mobile Satellite Services (MSS) Reporting Terminal, Broadcast Terminal, Satellite Mobile Radio (SMR) Terminal and Portable Multimedia Terminal (PMT), were developed and demonstrated their applications to various user agencies using GSAT-6 MSS satellite. MSS Reporting Terminal is a battery-operated hand-held terminal at S-band with an in-built GPS receiver. Broadcast Receiver is an S-Band DVB-S based receive-only terminal capable of receiving multi-channel audio/video and data simultaneously. SMR supports two-way voice communication on a basis of terminal-to-terminal and terminal-to-PSTN/Mobile network. PMT supports two-way IP data communication for terminal-to-terminal and terminal-to-HUB requirements.

Advanced MSS Satellite- Hub System

INSAT MSS Type-D Hub station is installed at AES with 6.3m C-band antenna and RF system is augmented for GSAT-6 application demonstration such that both INSAT & GSAT MSS can work with minimum user interface. For testing of RF system without satellite SXC, CXS and CXC TLT is also installed. Hub baseband was developed & integrated with the RF Hub and terminals. Various applications were demonstrated and the Hub was integrated with different terrestrial interfaces like PSTN, VoIP, GSM, SMS and Internet.

Advanced MSS Satellite- Applications

MSS Network for Warning at Un-Manned Level Crossing (UMLC): An MSS Network is conceived for and proof-of-concept (POC) demonstrated to Indian Railways to support warning siren / visual alarm at UMLCs and Emergency Communication.



Monopulse Tracking System for Earth station

GSAT-11

The next-generation Ku/Ka communication satellite GSAT-11 is currently under development at ISRO. It is a High Throughput Satellite (HTS) and its application shall primarily focus on meeting the country-wide demand for satellite based broadband applications. SAC is responsible for Ka- Band Ground Segment Establishment and On Board Tracking receiver and tracking system development. The Project proposal cleared by SPAC and project team is formed.

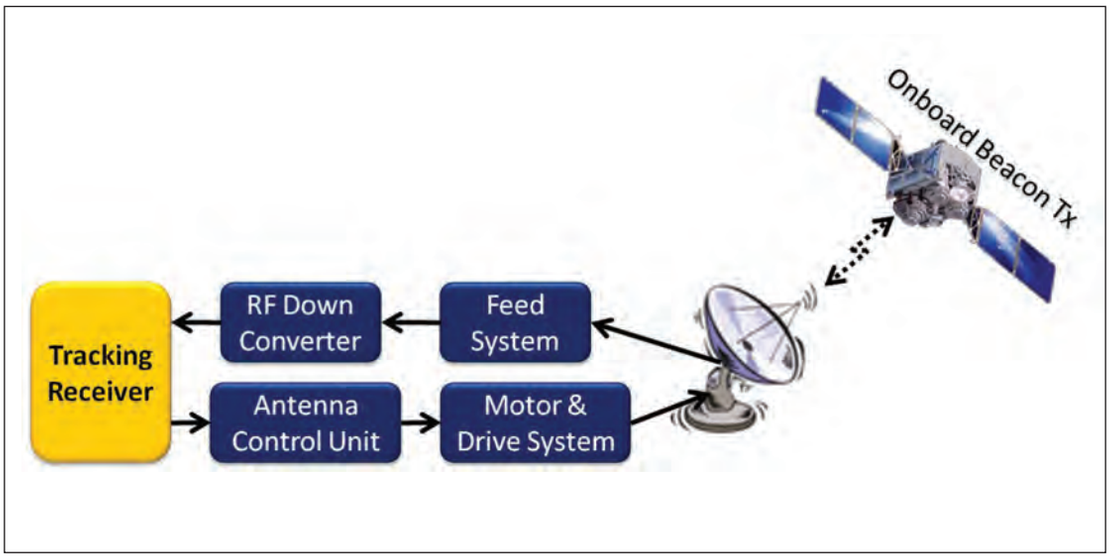
GSAT-19

Development of Onboard Tracking System & Tracking Receiver
SAC is responsible for design and development of onboard tracking system to track and point the two Ku band antennas with minimum hardware. The system design of tracking system & tracking receiver is completed and development of two tracking receiver FM units is in progress.

New Technology Development

Monopulse Tracking Receiver for Earth Stations

Development of Generic Digital Monopulse Tracking Receiver has been taken up to cater the tracking requirements of Earth stations having single channel or two-channel monopulse tracking system.



Monopulse Tracking System for Earth station

POC model Generic Digital Monopulse Two Channel Tracking Receiver is developed for Earth stations and single channel is in progress.

IRNSS (NAVIC)

A signal monitoring facility with 6.3m antenna was installed to check the signal quality of IRNSS signal at without any processing. The facility supported IOT of IRNSS 1E, 1F and 1G satellites. Regular monitoring of IRNSS/GNSS signals are being carried out by this facility. Field trials of user receivers are being conducted on regular basis. This has resulted in revealing various interferences from terrestrial sources like TV towers. Data analysis of in-house and Septenentrio IRNSS Receiver are also in progress.

6.3m L&S Band antenna & SIGMON system

In-house simulator capable to generate ionospheric & troposphere effects was developed and tested successfully with in-house receiver for long hours. The software for simultaneous generation of 52 week long code for all satellites is developed. Development of GUI for long code generation software is initiated so as to provide a common interface for parameter generation and code generation. The In House IRNSS Simulator is demonstrated live to users from academic institutions and industries in the IRNSS User Meet held in SAC.

Three receivers, In-House Developed SPS and RS Rx and Industry developed SPS_GPS Rx, were tested and IRNSS SPS and RS positioning results were found to be within 6-8 m and comparable to GPS positioning. A user friendly utility software named IRDAS (IRNSS Receiver Data Analysis Software) is developed for automatic generation of plots and analyze the large volume of data generated by IRNSS user receivers deployed across India. Establishment of 6.3 M Antenna system and 168 hours burn-in test of Data Acquisition & Recording System for IRNSS Signal Monitoring Facility was completed. Field trial data analysis was carried out for ACCORD IRNSS receiver and Indradhanush GPS receiver. The IGS Receiver unit was demonstrated at ISRO Pavilion in MAKE IN INDIA Mumbai week exhibition.

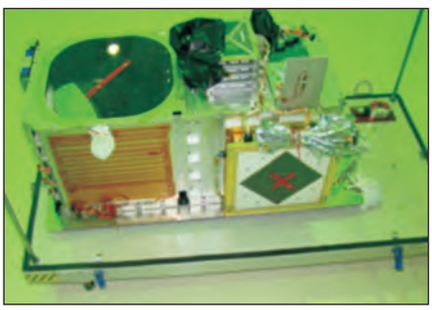
Remote Sensing Payload

Development

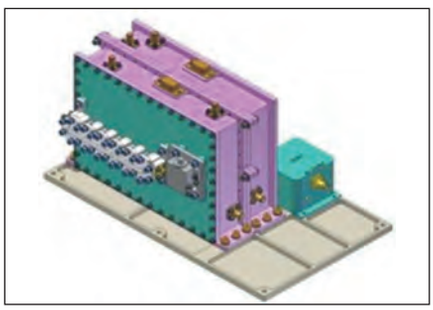
SAC is developing Optical and Microwave Remote Sensing payloads for Low Earth Orbit (LEO), Geostationary Orbit (GEO) and a Lunar mission for different applications like Earth observations, Meteorological applications, planetary missions and airborne applications. These include Cartosat-2 Series, Cartosat-3/3A/3B, Oceansat-3/3A, Resourcesat-2A, Resourcesat-3A/3S, INSAT-3DR/S, GISAT-1, GISAT-2, Chandrayaan-2, Aditya-L1, NISAR, SCATSAT 1, RISAT 1A and RISAT 2A.

INSAT-3DR/S

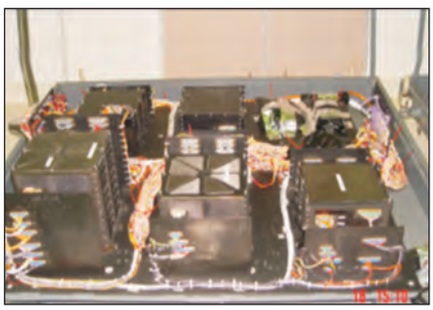
INSAT-3DR has 2 meteorological payloads; Imager & Sounder and DRT/SAS&R receiver. It will provide enhanced meteorological observation and monitoring of land and ocean surfaces as well as weather forecasting and disaster warning. Both the optical payloads were shipped to ISITE on 19th November 2015 and communication payload of INSAT 3DR was flagged of on March 16, 2016.



Imager payload



New DRT/SAS&R Receiver



Sounder payload

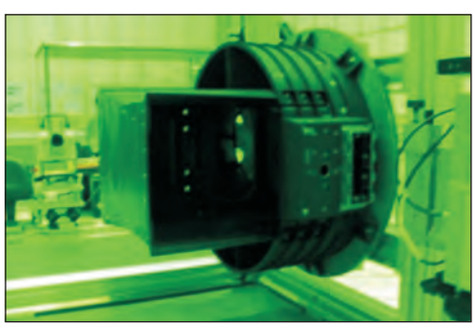
INSAT 3DS, the flight worthy ground spare is a follow on of INSAT-3D/3DR. Subsystem development is under progress. Camera electronics package assemblies and functional testing have been completed. Incoming Inspection has been completed for Thermal implementation aspect for North plate. Plate level thermal implementation is to be initiated.

RESOURCESAT-2A

Resourcesat-2A, follow on mission consisting of 4 payloads; LISS-3*, LISS-4 and AWIFS-A&B. LISS-3* payload has been realised and delivered to ISAC, Bangalore on 17th August 2015 for further activities. LISS-4 payload is realized and successfully undergone test and evaluation followed by radiometric, light transfer characteristics (LTC) and spectral calibration. LISS-4 payload is likely to be delivered to project during June 2016.

Subsystems for VNIR chains of AWIFS-A&B payloads are over. Optimization and vacuum verification for VNIR chains is completed. Characterisation of EM, QM and one FM SWIR detector is also completed. Design of electronics required for SWIR detector is completed and cards are under fabrication. Interfaces are finalised.

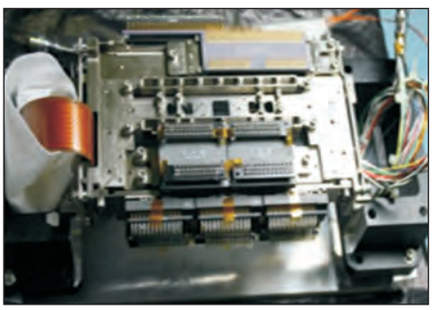
Newly developed ISPD compliant Checkout & Evaluation software with increased capability and features was deployed for RS-2A payloads development.



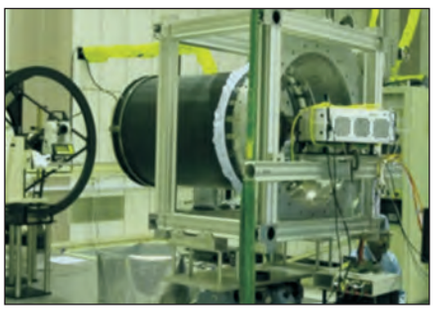
LISS-4 Payload

CARTOSAT-2 C

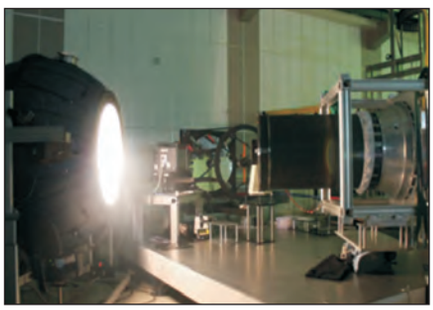
Cartosat-2C, the next payload in the Cartosat-2 series provides spatial resolution of 0.63 m PAN and 1.57 m MX bands with an operational life of 5 years. Time Delay and Integration (TDI) detector with enhanced radiometric performance will ensure continuous imaging. The payload is realised. PSR is completed on 28th March 2016. Payload is delivered to ISAC, Bangalore on 29th March 2016.



Detector Head Assembly



Cartosat 2C Payload

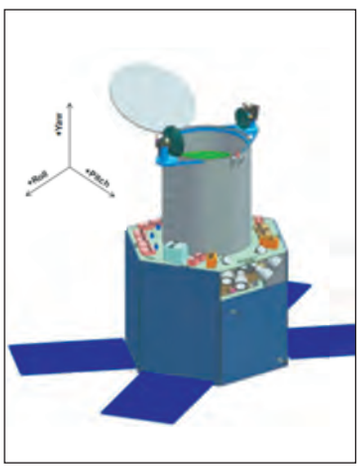


Light transfer characteristics

CARTOSAT-3

Cartosat-3 is a highly agile advanced satellite having imaging capability with a very high spatial resolution of 0.25m in panchromatic and 1m in multi spectral with an operational life of 5 years. The agile spacecraft platform has many new technologies supporting this mission to manage and handle high payload data rates, agile enough to obtain more spots and strip images during a pass and has a stable platform with good control and location determination. The onboard subsystems are configured with appropriate specifications to meet the set mission requirements. All the sub system design is finalized and firmed up after optimization. Cartosat-3 payload level PDR was completed successfully in January, 2016.

Spacecraft stowed view



Spacecraft deployed view

Hyper Spectral Imaging Spectrometer (HYSIS)

HYSIS mission will provide global coverage on repetitive basis to users and also supplement the existing multi-spectral missions. The spaceborne Hyper Spectral Imaging Spectrometer (HYSIS) will provide earth surface image in VNIR (0.4 to 0.9 m) and SWIR (0.85 to 2.4 m) spectral region of the electromagnetic spectrum in 64 contiguous spectral bands in each spectral range with 10 nm bandwidth. It will provide 30 m spatial resolution and a swath of 30 km.

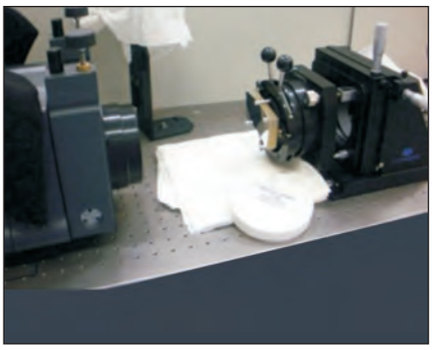
Design & Simulations of various functional blocks of SWIR Front End Camera Electronics is completed. VM development for SWIR FECE with 14 bit AFE (LM98640) is in progress.

HYSIS SWIR FECE Logic Card

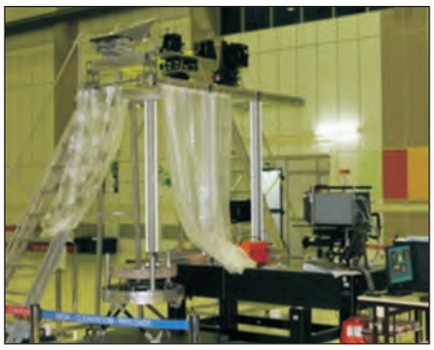
HYSIS SWIR VP BBM

GISAT

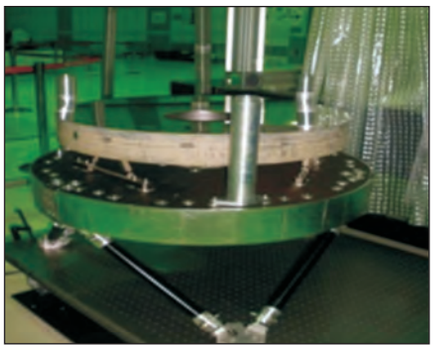
GISAT consists of Multi-spectral and Hyper spectral cameras. The sub-systems/sub-assemblies for the Electro-optical (EO) payloads are being realized. The bread-board models (BBM) of camera electronics packages are nearing completion. Optimization of DVM of telescope is in progress. Subsystem development of communication payload is in progress.



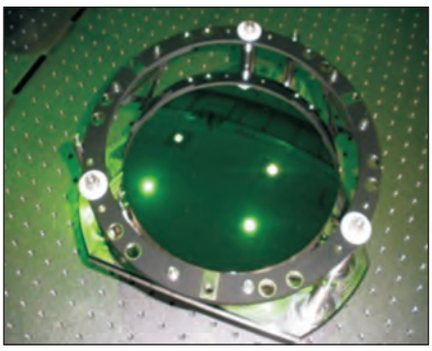
HYS VNIR and HYS-SWIR bread board mirrors characterization and bonding



Null-lens test setup for GISAT ETM Primary Mirror surface figure characterization

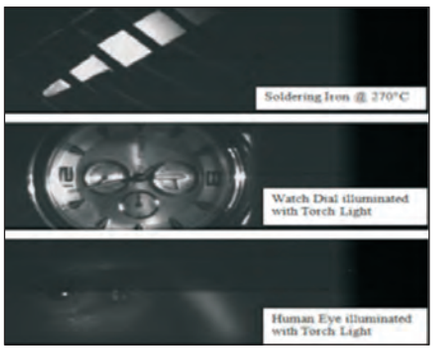


ETM Primary mirror assembly with MFD on the DVM optical bench



GISAT ETM Secondary mirror bonding in its mount

SWIR IDCA Dummy model

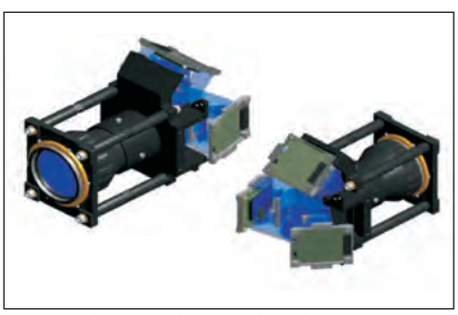


Imaging carried out with SWIR IDCA

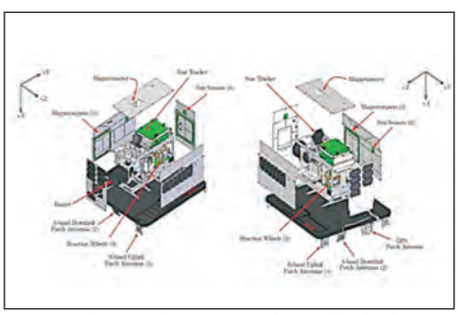
NEMO-AM

NEMO-AM is a Nano-satellite for Earth Monitoring and Observation – Aerosol Monitoring (NEMO-AM) which is being developed as per the agreement between ISRO and Space Flight Laboratory (SFL), Canada. It is a low mass, compact and three axis stabilized satellite. It is planned to be launched in sun-synchronous orbit of altitude of ~500 km. The satellite is capable of tracking a target having image acquisition capability at seven different viewing angles (±53 deg) with sub degree pointing accuracy. NEMO-AM science work shop was held in April 2015.

Preliminary Design Review (PDR) and Critial Design Review (CDR) are completed. Development of instrument electronics is completed and Optics development is in progress. Launch interface details are received and provided to PSLV team for feasibility study.



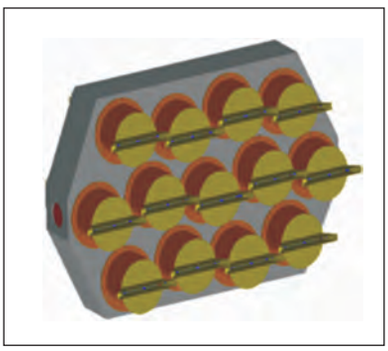
Multi–Angle Dual Polarisation Imaging sensor instrument on NEMO-AM



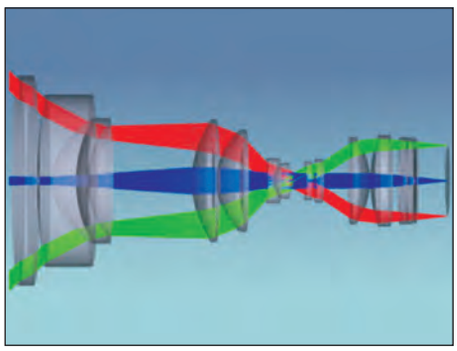
NEMO-AM Spacecraft exploded view

OCEANSAT-3

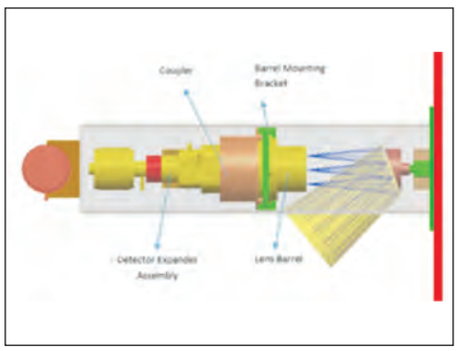
It is planned to launch Oceansat-3 as a continuation mission to Oceansat-1 and Oceansat-2 to cater to the user needs for various oceanographic applications. Oceansat-3 has three payloads – Ocean Colour Monitor – 3 (OCM-3), Sea Surface Temperature Monitor – 1 (SSTM-1) and Scatterometer. Configurations for all payloads are finalized and the subsystems are in various stages of development.



OCM-3 Payload Schematic



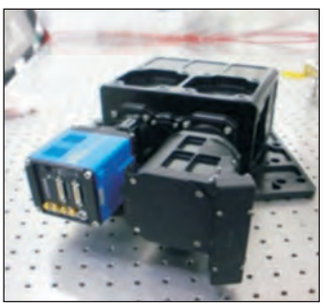
OCM-3 Optical Design Configuration



SSTM-1 Payload Schematic

AIRBORNE SENSORS

Airborne Hyperspectral Imager (AHYSI) and Airborne Imaging Spectrometer (AIMS-2) were flown at various places in India.

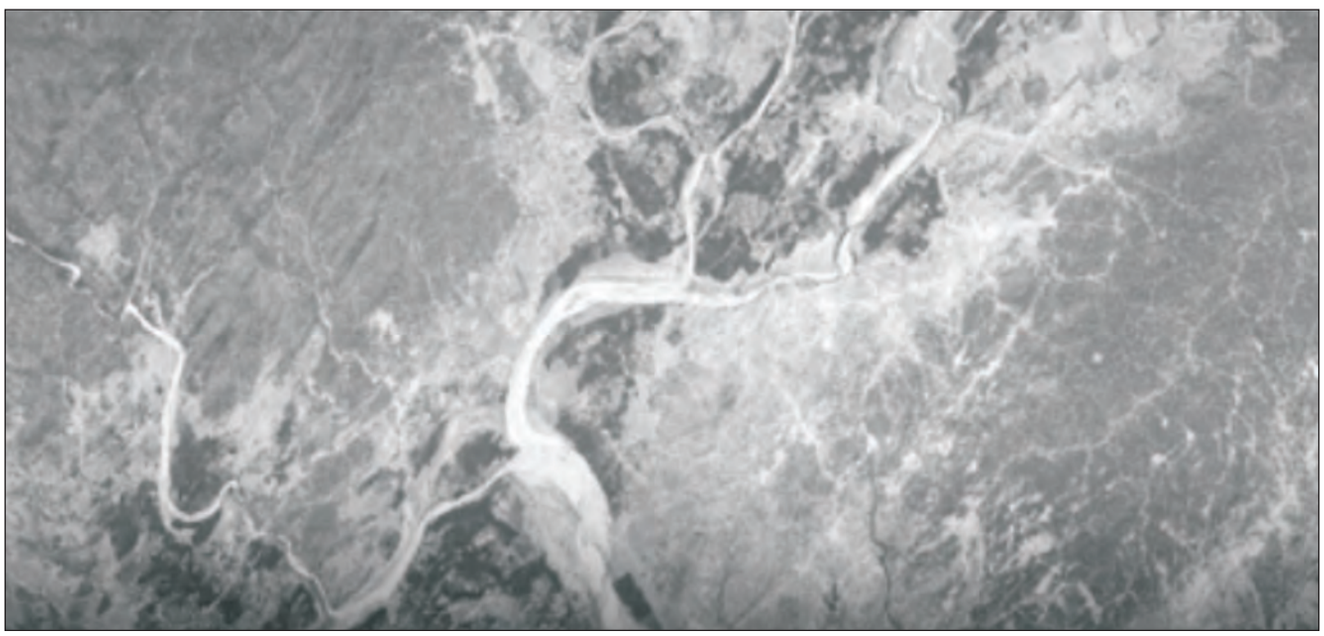


AIMS-2 Hyperspectral Imager

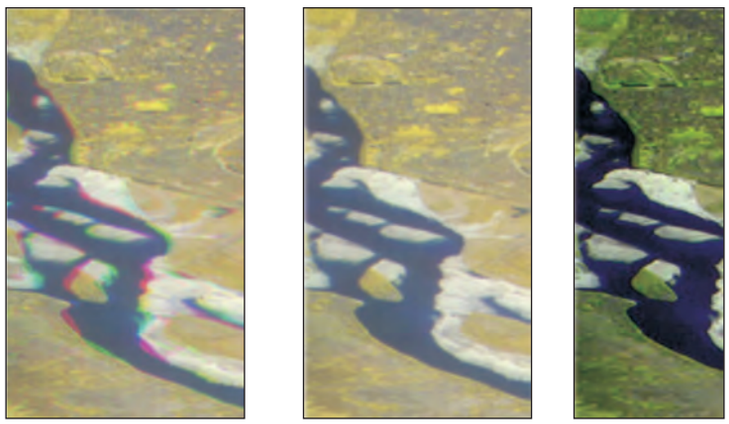
Image taken by AIMS-2

AHySI

Image taken by AHySI

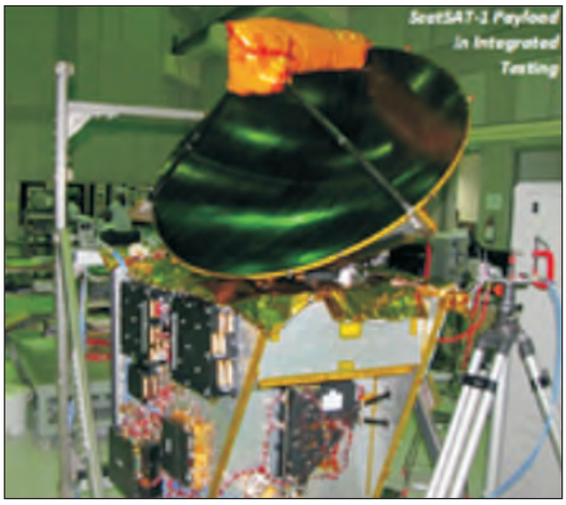


Band-3 ANANO Image over Gaya (ARC Flight)



Band Registered and Colour corrected AHySI Image using IMU Data

ScatSAT-1



ScatSAT-1 is the follow-on mission to OSCAT and is on a fast-track realization. Advancements in the payload over the earlier mission include an enhanced on-board signal processor, ability to upload software patches, captive payload telemetry unit and better failure tolerance with cross-patching of critical subsystems between main and redundant chains.

All subsystems level T&E were completed. Integrated payload was thoroughly tested and characterized.

Conducted Pre-launch User-Meet to assess user feedback and refine the processes for climate quality data.

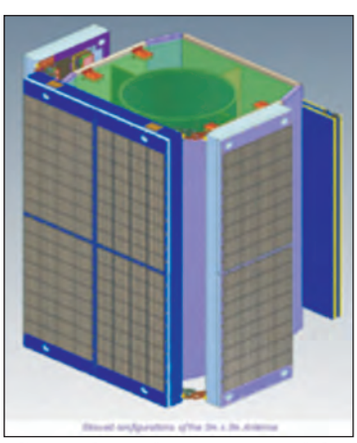
RISAT-1A

As a follow on mission of RISAT-1 initiated development of various sub systems of RISAT-1A. Improved design of multi layer printed antenna to achieve high gain is carried out by changing the configuration suitably. Design optimization and development of single element based on new design is completed.

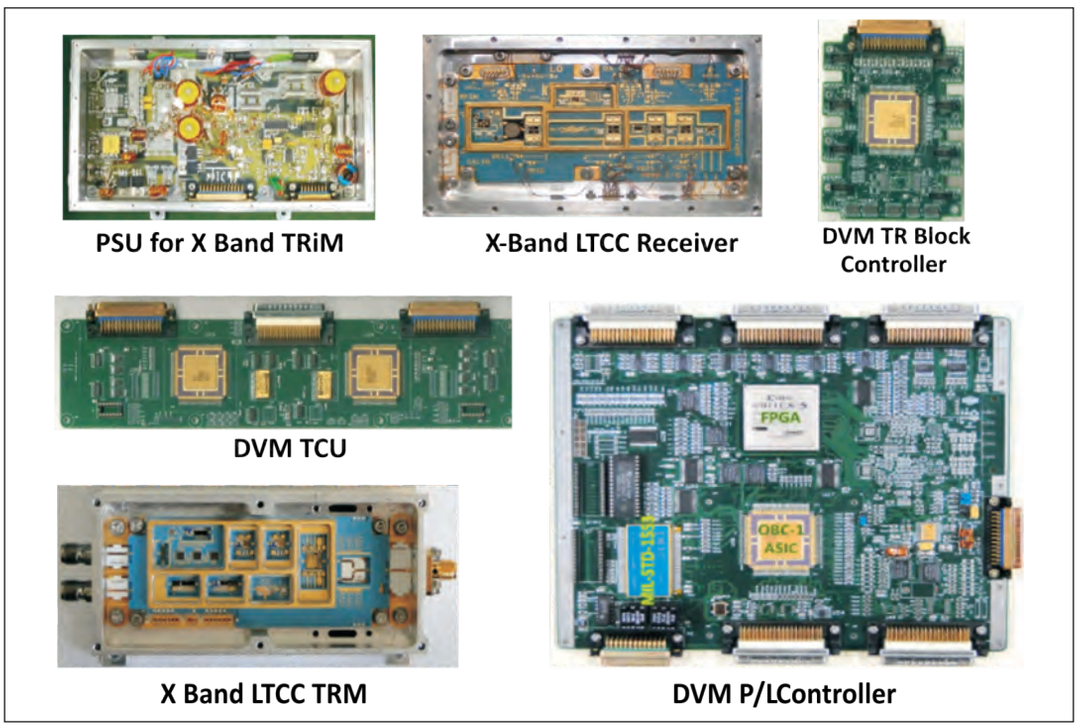
RISAT-2A

RISAT-2A is a continuity mission of RISAT-2 which was an outsourced payload from Israel. RISAT-2 would provide services in X-Band & is to be made in India.

Antenna configuration was finalized from the prevailing options (256 TR Modules on a 3mx3m layout); LTCC layout design for 10W X-band TR module and prototype TR-LTCC module fabrication is completed. Package design for TRiB (TR module Integrated Block, comprises 8 TRMs, One TR control, RF power distribution network and power supply unit) along with thermal analysis for LTCC TRM & full TRiB assembly is also completed. Layout design of TRIB assemblies and other active antenna hardware on the antenna structure is finalized. Realized DVM hardware of Payload controller along with MIL-STD-1553B BMU Simulator and GCU. Also completed development of CGDACS (Ultra high bandwidth chirp generation and quantization with data compression) DVM hardware.



Stowed configurations of the 3m x 3m Antenna



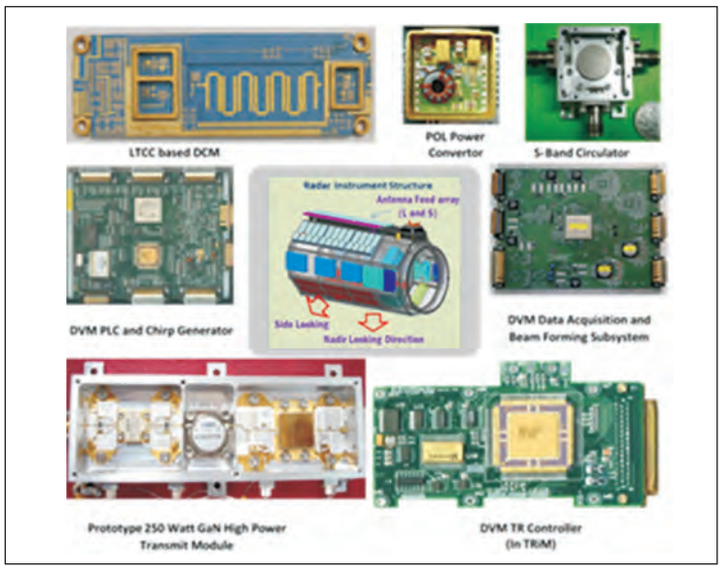
NISAR

This collaborative effort between ISRO and NASA is a dual band SAR instrument in which SAC contributes an S-Band Sweep SAR and JPL provides an L Band instrument, sharing a single 12m reflector.

System design and configuration is finalized.

Indigenous design and development of all MMICs for TRiMs and DCMs, LTCC layout design and prototyping of TR module with in-built calibration is complied. Also the design and development of prototype 250 Watt GaN based High Power Transmit Module and in-house S band Circulator for High Power Duplexer Module is completed.

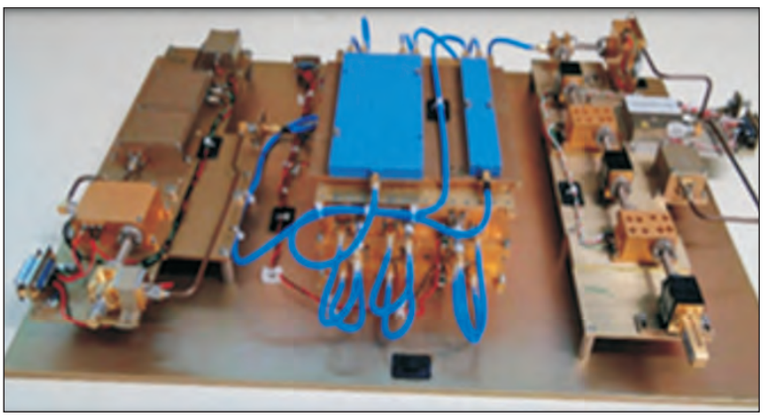
DVM EPC for TRiM, PLCG and POL converters is developed. DVM DABF with ADC characterization and Matlab simulation of digital beam forming is completed.


LTCC based DCM
POL Power Convertor
S-Band Circulator
Radar Instrument Structure
Antenna Feed array (L and S)
Side Looking
Nadir Looking Direction
DVM PLC and Chirp Generator
DVM Data Acquisition and Beam Forming Subsystem
Prototype 250 Watt GaN High Power Transmit Module
DVM TR Controller (In TRiM)

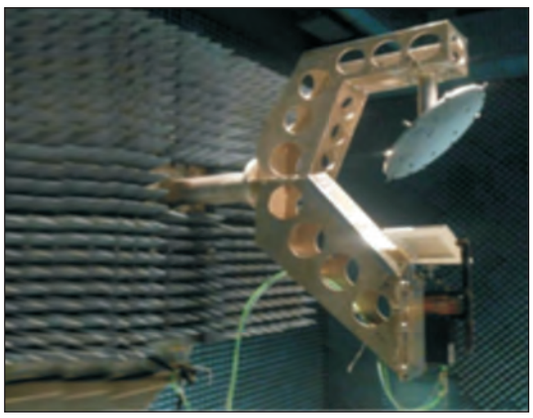
Design and optimization of one-third S band microstrip feed array antenna with eight element pairs at S-Band along elevation is carried out. One-third S band feed antenna is fabricated, integrated on Aluminum baseplate with CFRP face skin. Optimization of Microstrip feed array with Wilkinson power divider is also carried out.

Millimeter Wave Humidity Sounder Units (HSU)

HSU, a 6-channel total power radiometer is an instrument configured with a surface observation channel at 89GHz and 5 sounding channels in the 183±16 GHz band and onboard blackbody and cold sky calibration embedded in the scan cycle. The instrument is expected to yield 2km vertical resolution in the 0-10km range.



Receive chains pushing the frequency to nearly 200GHz.



HSU Antenna characterisation with FSS at 167-195 GHz

Front end subsystems of 89 GHz and 183 GHz receivers are developed and receive chains are characterized. DVM High Precision Data Acquisition System development and characterization is completed along with AGC loop. Antenna along with FSS was successfully characterised at 167-195 GHz. The FSS is used to transmit 167-195 GHz band and reflect the 87-91 Ghz.

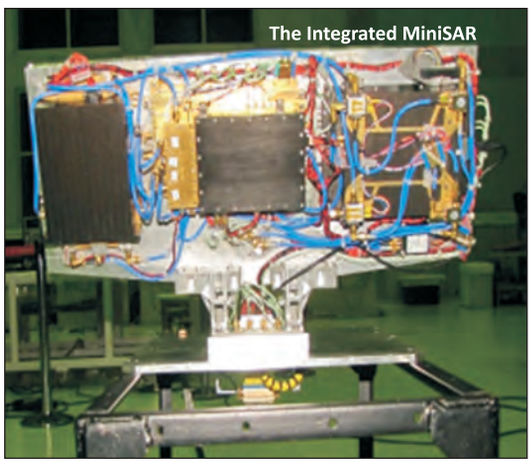
L & S Band Airborne SAR

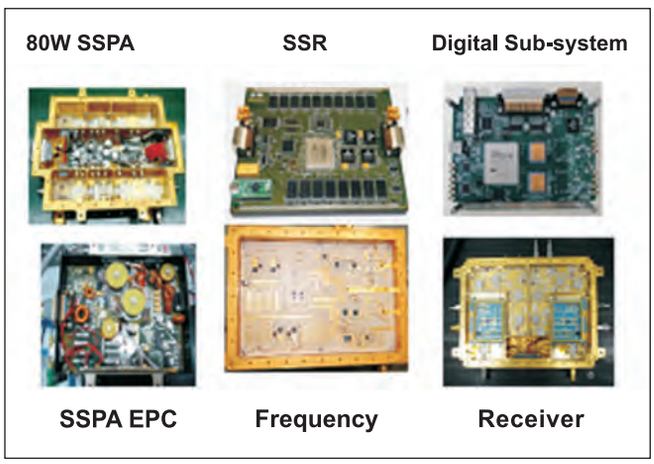
System configuration is finalized and digital, RF, power and other subsystems are under realization. Baseline Design Review (BDR) is completed. Interface details are frozen and generated ICD along with final data format.

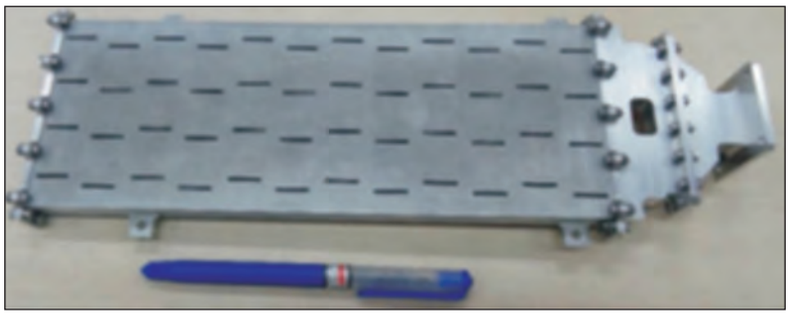
Airborne MiniSAR

The instrument is optimized for a flight altitude of 3 to 10km and is designed for a best case resolution of 0.3m in a 5km swath.

Completed the development of 80W X-Band GaN SSPA with 45dB gain, 686 W Pulsed EPC, and digital subsystems. The design, development and characterization of 4 x 12 planar array antenna for X band MiniSAR using matching technique is completed. The system is integrated and tested extensively, including characterization.



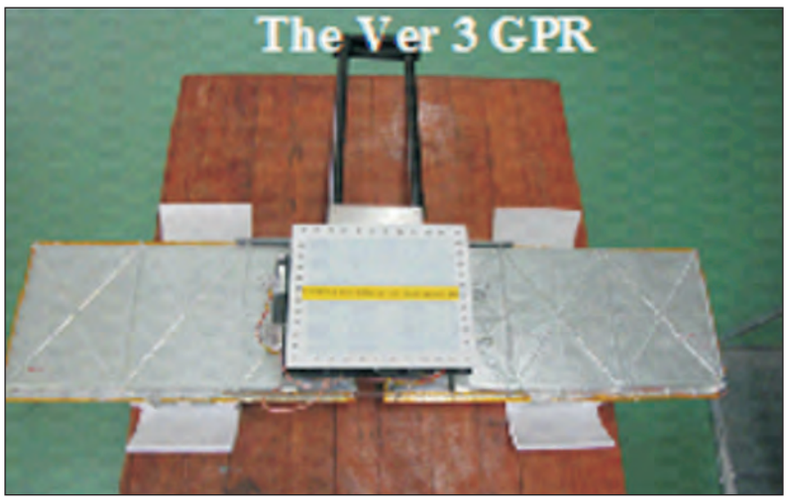




4 x 12 broadband lightweight linearly polarized fed SWA antenna

Ground Penetration Radar(GPR)

The third version of the GPR was calibrated relative to a commercial GPR. The instrument applied at Antarctica for Snow and Ice studies as part of the 35th ISEA.



Ground Based Scatterometer

The instruments is realized in the C-Band and configured conveniently on a mobile tower with 25° to 65° look angle coverage and a dynamic range in excess of 50dB.The development and testing of the GB Scatt is completed. The system is calibrated with standard targets and characterized. Repeated Field trials are conducted and compared with RISAT-1 data.

Field tests

Planetary & Astronomical Missions

Towards its Planetary and Astronomical Missions, SAC has achieved following milestones during the year:

CHANDRAYAAN-2

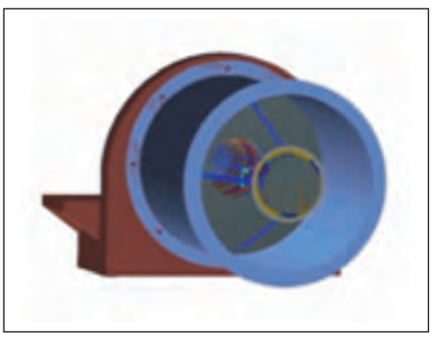
Chandrayaan 2 is follow on mission of Chandrayaan 1. It consists of Optical and Microwave sensors.

Optical Sensors

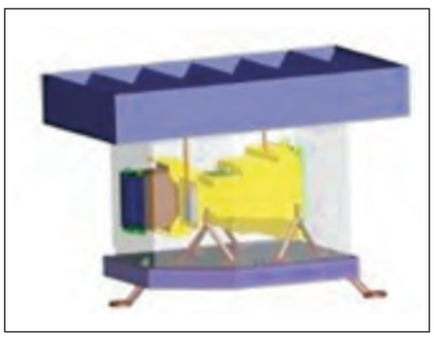
The development of all the two instruments, Terrain Mapping Camera-2 (TMC-2) and Imaging IR Spectrometer (IIRS) is in advanced stage. Third instrument Rover Imager is delivered for spacecraft integration after completion of T&E.

EO sensors - Orbiter High Resolution Camera (OHRC), Lander Position Detection Camera (LPDC), Lander Hazard Detection and Avoidance Cameras (LHDAC) are identified for the navigation and safe landing on moon surface. Configuration study of these instruments is carried out, PDR is completed and development is in progress.

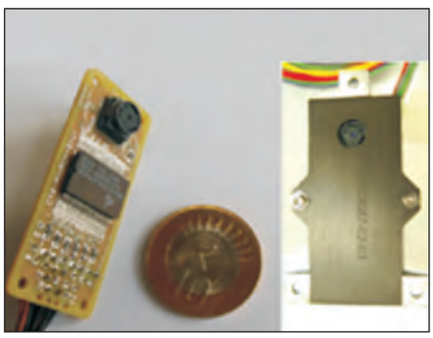
In order to cater to Checkout requirements of RI, TMC-2 and LHDAC, new hardware including 5 units were developed and operationalized.



OHRC Payload CAD Model



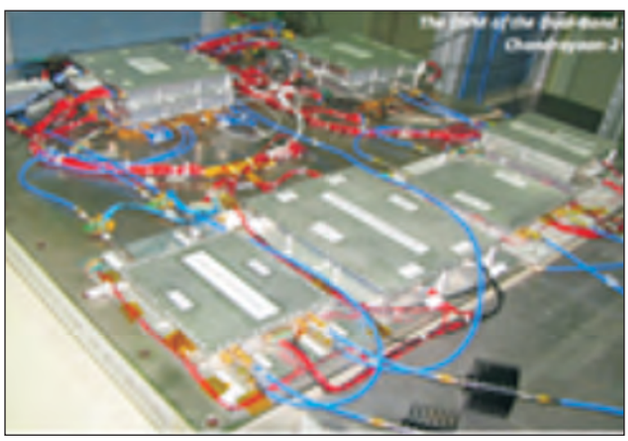
IIRS CAD Model



Rover Imager FM Payload

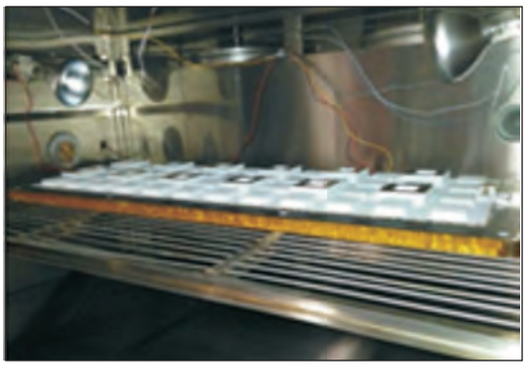
Microwave Sensors

SAR Payload: The orbiter SAR for Chandrayaan-2, is configured to operate stand-alone or simultaneously in L- and S- bands, sharing a common antenna. Inter-payload and intra-payload interfaces were finalized and generated ICDs.



FM realization activity is in progress. The design verification model of Shared Aperture Dual Band Dual Polarized Antenna is designed and developed. A qualification sample of one fourth antenna on CFRP base plate is developed. The vibration and thermo vacuum qualification for antenna with connectors and cable

assembly for wide temperature range of-1300C to + 1200C is carried out.



1/4 Qualification Sample Antenna in Thermal Cycle

Ka-band Altimeter and Hazard Detection cum Avoidance System for Chandrayaan 2 Lander: A Ka-Band FMCW Radar Altimeter providing real time height and vertical velocity estimation will assist the lander module of Chandrayaan-2 from an altitude of 7 km to touchdown. The system sports an inherently high tolerance to pointing error; the subsystem co-houses a real-time Hazard Detection and Avoidance processor to process optical data from a pair of cameras and guide the spacecraft to a safe landing.

The DVM subsystems for Altimeter is integrated and tested thoroughly. Delay line based validation and extensive field characterization on different types of terrain, both indoor and outdoor are completed. Version-2 DVM & FM configurations and IGIS and SSR interfaces for field tests are finalized and interface requirements are worked out for Lander Sensors Performance Tests (LSPT) and Pad Abort Tests for HSP.

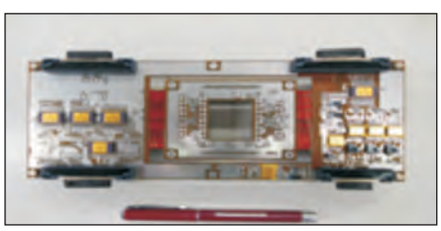
HDA Processor DVM Hardware is realized and firmware development is under progress.

ADITYA-L1

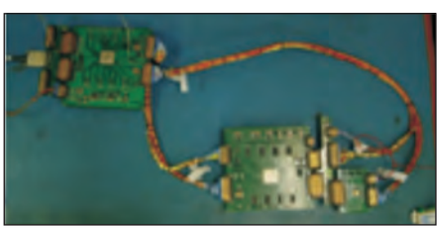
Aditya-L1 mission is planned to investigate the physical processes of sun like heat of the solar corona, solar wind and coronal mass ejections (CMEs). SAC is responsible for design and development of detection systems of coronagraph. The coronagraph instrument will perform spectroscopic and spectro-polarimetric observation of solar corona from Lagrange point L1 . Scientific objectives are:

- Diagnostics of the coronal plasma
- Study the cause of exceptionally high temperature of corona
- Development, dynamics and origin of CME
- Measurement of coronal magnetic fields in the corona

Preliminary design of DHA is completed. Control and Digital Processing Electronics (CDPE) of BBM of visible channels is developed and tested independently. Detector Proximity electronics (DPE) PCB is under fabrication. Power supply procurement is initiated. Electronics development is in progress. BBM is designed and fabricated.TC/TM interface was finalized.



ADITYA DPE BBM



DCPE BBM & TU

Earth Observation

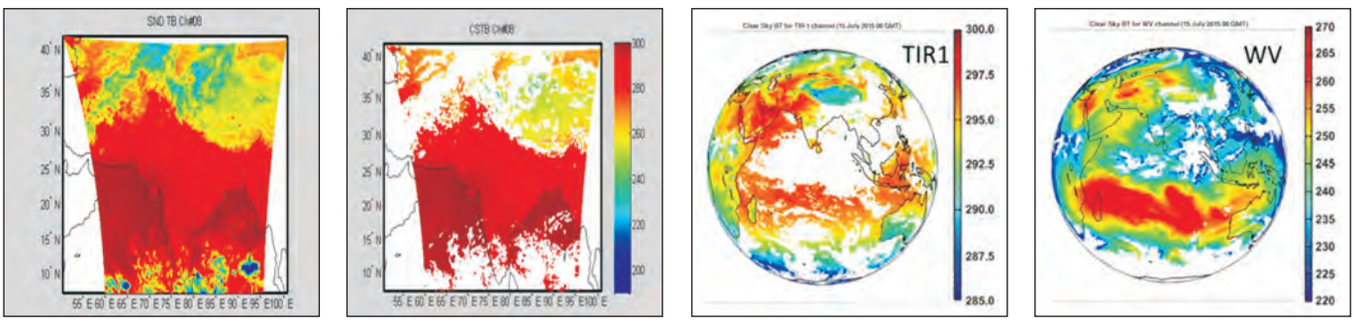
Applications

SAC carried out Earth Observation applications in the field of Agriculture, Water Resources, Environment, Climate Change, Meteorology, Oceanography and Planetary Sciences. It involves retrieval of geophysical parameters, data assimilation, improved weather and ocean state forecasts, Polar ice studies, studying climate change and sensor system definition studies etc.

Data Retrievals/Assimilation

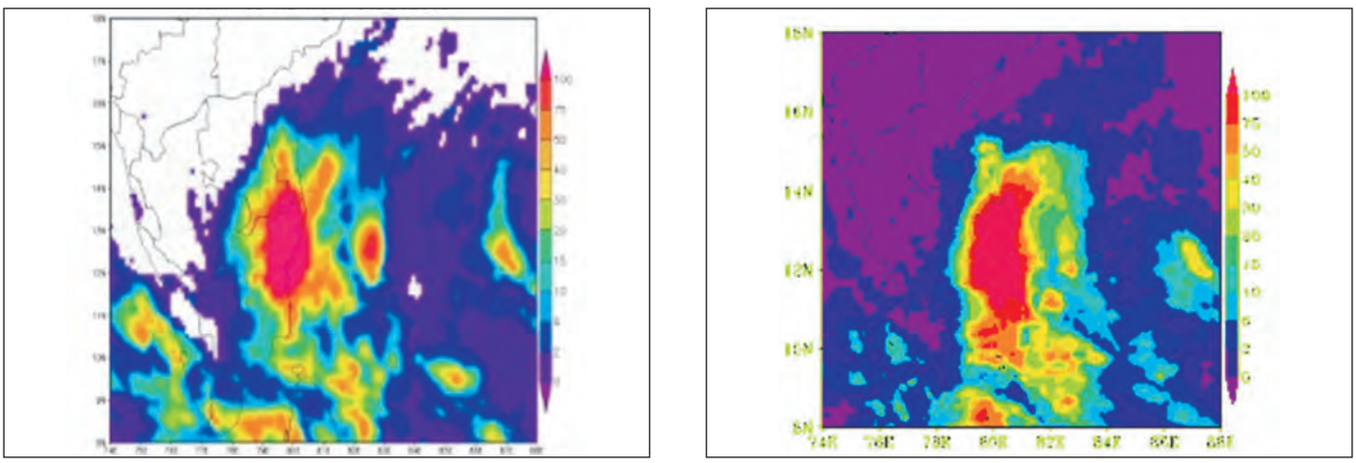
INSAT-3D Data Retrievals

Clear-Sky Radiance Products from INSAT-3D Imager/Sounder: Developed an algorithm for the clear-sky Radiance/brightness temperature (CSTB) products from INSAT-3D Sounder and Imager for radiance assimilation. Sounder CSTB products are operational in IMDPS and used in the operational NWP models by NCMRWF, IMD and SAC.



INSAT-3D CSBT product for sounder Channel 8 (left 2 panels) and for imager (right panels)

Modified Hydro-Estimator: Modified algorithm for rain rates from Hydro-Estimator is implemented since August 2015 for operational retrieval at IMDPS. The new algorithm adjusts the dry bias in the hilly terrain, incorporates new procedures for measuring orographic corrections and equilibrium level corrections. The H-E rain from modified algorithms is also assimilated in NWP models that provided improvements in the forecast skills.



H-E Rain over Chennai on 01 Dec 2016 (left) and corresponding GPM-IMERG rain (right)

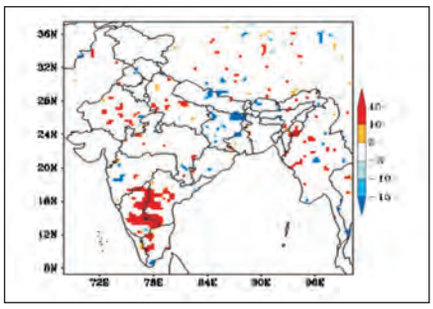
OSCAT Retrievals

Ocean Currents: Algorithms are developed to derive daily ocean surface currents employing the Geostrophic and wind driven Ekman solutions by the synergistic use of multi satellite data (OSCAT/ASCAT/CCMP,Raynold SST, AVIOS). These algorithms are made operational in MOSDAC to generate daily ocean surface current product in 0.25^0 resolution

GNSS Retrievals/Applications

GNSS Reflectometry for ocean wind speed retrieval: A first-ever study of utilizing GNSS/Regional navigational systems (preparatory to IRNSS) for ocean surface wind speed information is carried out by retrieving wind speed from simulated ocean roughness using Elfouhaily wave spectral model. A non-linear regression model yields theoretical accuracy of 0.5m/s over the wind-speed range of 0-30 m/s. Processing of Delay-Doppler Map to obtain radar cross-section (NRCS) is also performed on the UK-DMC data, the first reflectometry mission from space

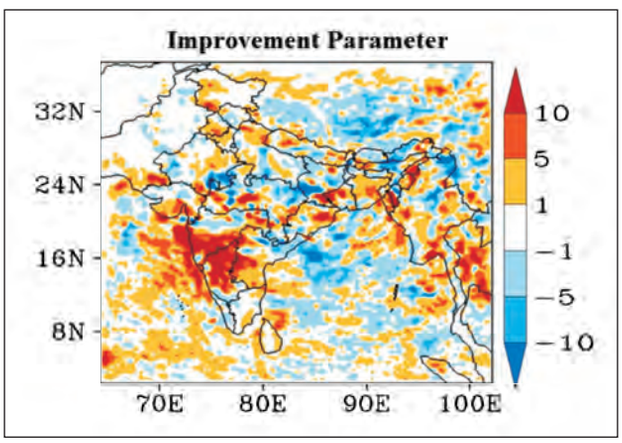
Integrated Water Vapor: A network of GPS receivers established under the GPS Aided Geo Augmented Navigation (GAGAN) project was used to estimate the zenith tropospheric delay (ZTD) and integrated water vapour (IWV) at the receiver locations. The IWV values were assimilated into WRF model and positive impact on forecast is found.



Impact of retrieved IWV values on WRF forecast.

INSAT-3D Utilisation

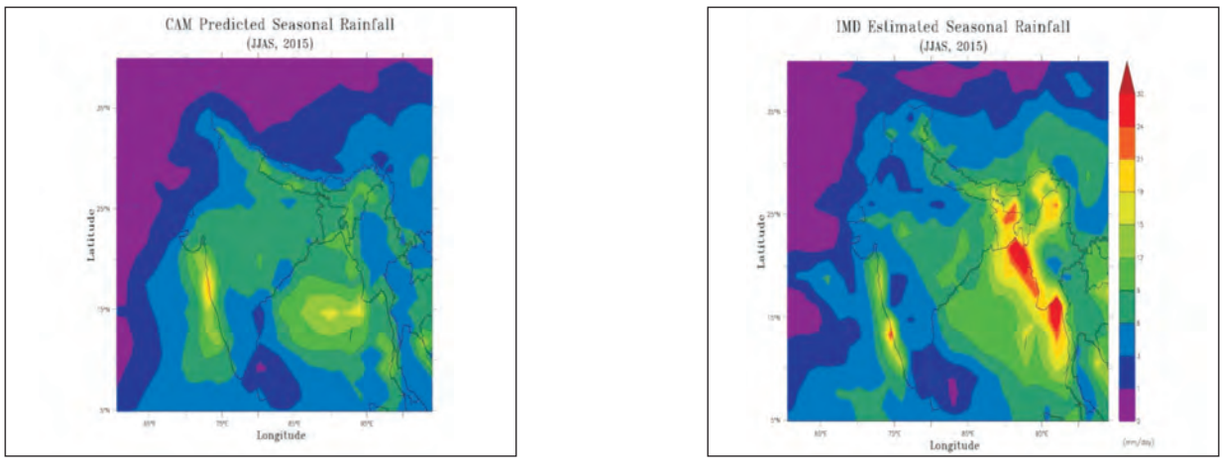
Assimilation of INSAT-3D Retrieved Rainfall on Short Range Weather Prediction: Preliminary comparison of INSAT-3D retrieved rainfall with TRMM merged rainfall and in situ observation from IMD during June-Sept is carried out. Various experiments performed daily with and without assimilation of rainfall observations during for the August 2015 show that assimilation of INSAT-3D rainfall makes good improvement of the temperature, wind speed and rainfall forecasts.



Rainfall prediction with the assimilation of INSAT-3D rainfall

Seasonal Forecast of Indian Summer Monsoon (ISM) 2015 using Ensemble Global Atmosphere Model CAM

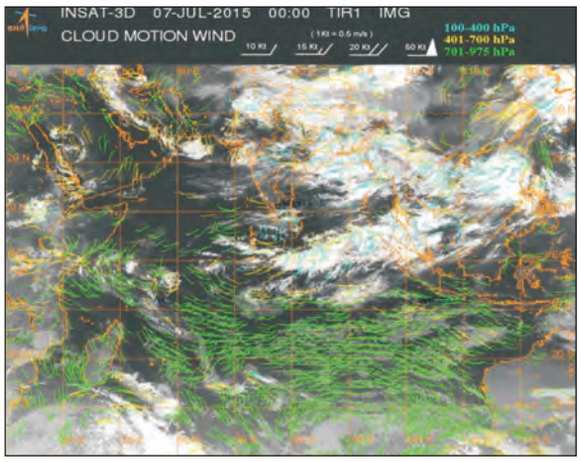
The aggregate rainfall over the Indian landmass during June to September was predicted to be 75.6 cm (87%) during June phase of experiment. The below average rainfall over India was well picked up in the model forecast. The direct comparison of model predicted seasonal rainfall during ISM 2015 is shown below.



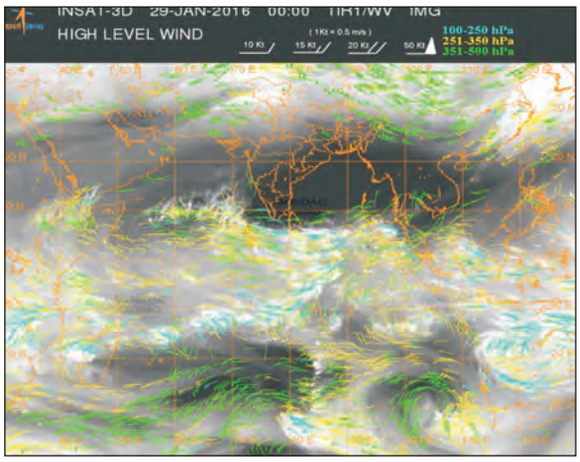
Comparison of CAM predicted seasonal rainfall (left) with IMD observation (right)

Assimilation of INSAT-3D Atmospheric Motion Vectors (AMVs) in the operational numerical models

The improved INSAT-3D Atmospheric Motion Vectors (AMV) retrieval algorithm was made operational in INSAT Meteorological Data Processing System (IMDPS) and accuracy of the new version of AMVs is well established as per the satisfaction of operational forecasting agencies.



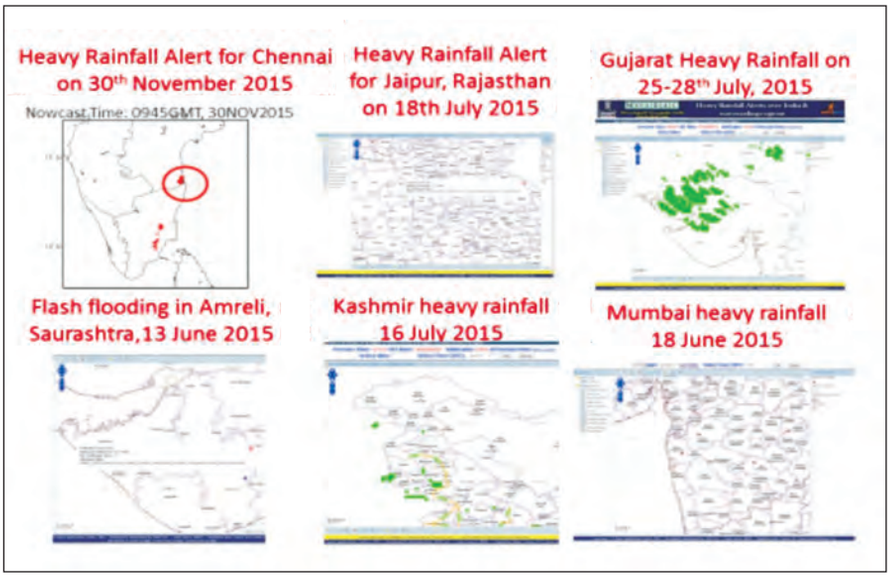
Cloud motion winds



High level wind from INSAT-3D

All India Heavy Rainfall Alerts

A satellite image based model is developed to provide heavy rainfall alerts over the whole Indian region and is regularly being posted and updated every half hourly on MOSDAC web portal. Since 2013, similar alerts were being provided for Uttarakhand and Himachal Pradesh through an in-house developed model NETRA. The model is now enhanced to include India and surrounding regions.

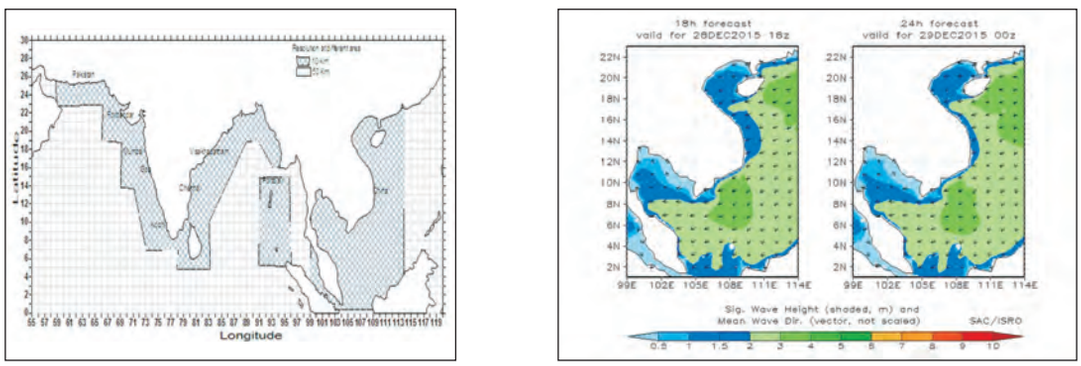

Heavy Rainfall Alert for Chennai on 30th November 2015
Nowcast Time: 0945GMT, 30NOV2015
Heavy Rainfall Alert for Jaipur, Rajasthan on 18th July 2015
Gujarat Heavy Rainfall on 25-28th July, 2015
Flash flooding in Amreli, Saurashtra,13 June 2015
Kashmir heavy rainfall 16 July 2015
Mumbai heavy rainfall 18 June 2015

Monitoring of Monsoon Progress 2015

The performance of monsoon 2015 was analyzed over Indian meteorological sub-divisional scale by the INSAT Multi-Spectral Rainfall Algorithm (IMSRA) using INSAT-3D data which is operational at MOSDAC. Qualitative and quantitative comparison of IMSRA with IMD gridded gauge based rainfall product suggest that IMSRA estimates have monitored rightly the below average monsoon 2015 rainfall over most part of India. Blue, Green and Red shows Excess, Normal and Scanty rain distribution respectively.

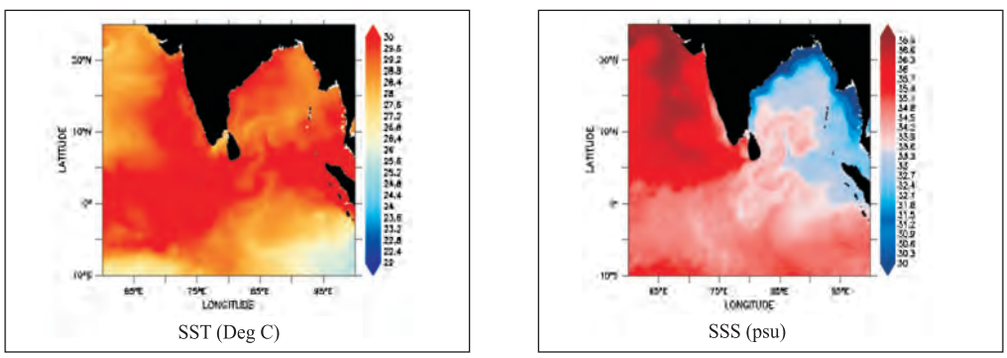
Data Assimilation, Numerical modeling & Advanced Ocean State Forecast

Wave forecasting system at SAC was augmented with WaveWatch -III model at 10 km resolution which is forced with NCMRWF winds. Optimum interpolation technique was used for assimilating the SARAL/Altika data in the model. The model was customized according to the requirement of Indian Navy and 6 hourly wave forecasts of the model was disseminated operationally to the Indian Navy using dedicated FTP site of MOSDAC.



Wave Model Domain (required by Navy, left figure), Sample output of wave in the south China Sea (right figure) from wavewatch-III operationally available to Navy

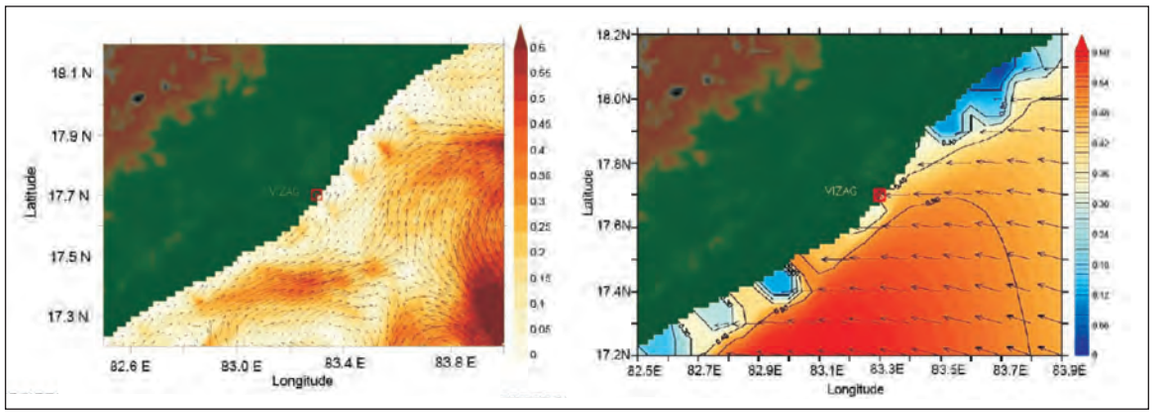
Ocean circulation model MOM-3 at 10 km resolution was configured and used to predict the ocean state depicting currents, temperature and salinity. It is also forced using the 25 km resolution NCMRWF wind products, and outputs are similarly provided operationally to Indian Navy for their routine fleet operations.



High resolution Sea surface temperature (Deg c, left figure) and Salinity (psu, right figure) from MOM-3 model. Outputs used by Indian Navy for fleet operations.

International Fleet Review (IFR) 2016 was organized during February 4-8, 2016 by Indian Navy near Visakhapatnam coast in which 50 nations participated. As per requirement of Navy, SAC provided 5 days forecasts of high resolution wave, swell, current, sea surface temperature, salinity for near the

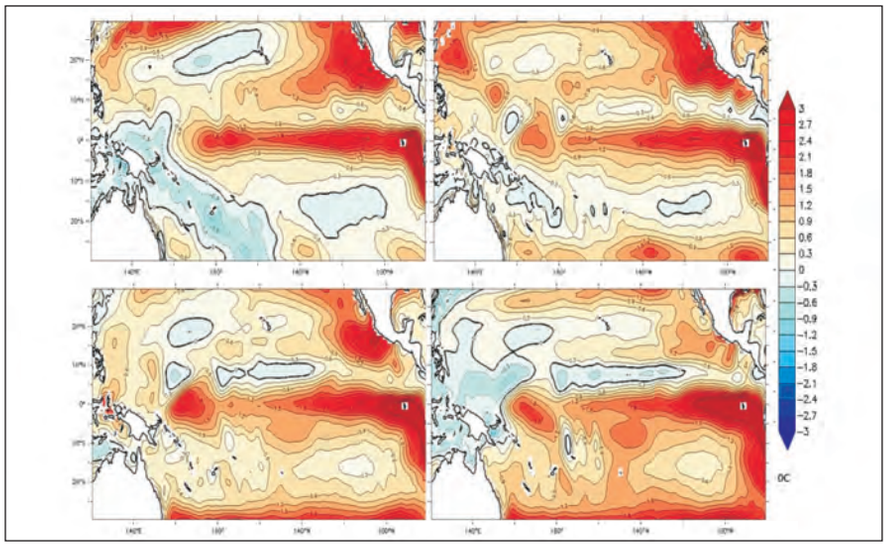
Visakhapatnam coast. Sea state forecasts required for the event was generated using the coastal wave model SWAN at 1 km resolution and circulation model MITGCM at 1.6 km resolution. Both models were forced



Sample output of current (left panel) and waves (right panel) provided during IFR

Ocean Process Studies

El-Nino is a global event that impacts the Indian summer monsoon very significantly. The in time prediction of El-nino is crucial for decision makers. This time the El-Nino outlook was predicted using a coupled model.



SST anomalies for various months (June, upper left; August, right upper; October, lower left; December, lower right) generated for El-nino outlook for 2015 using coupled model.

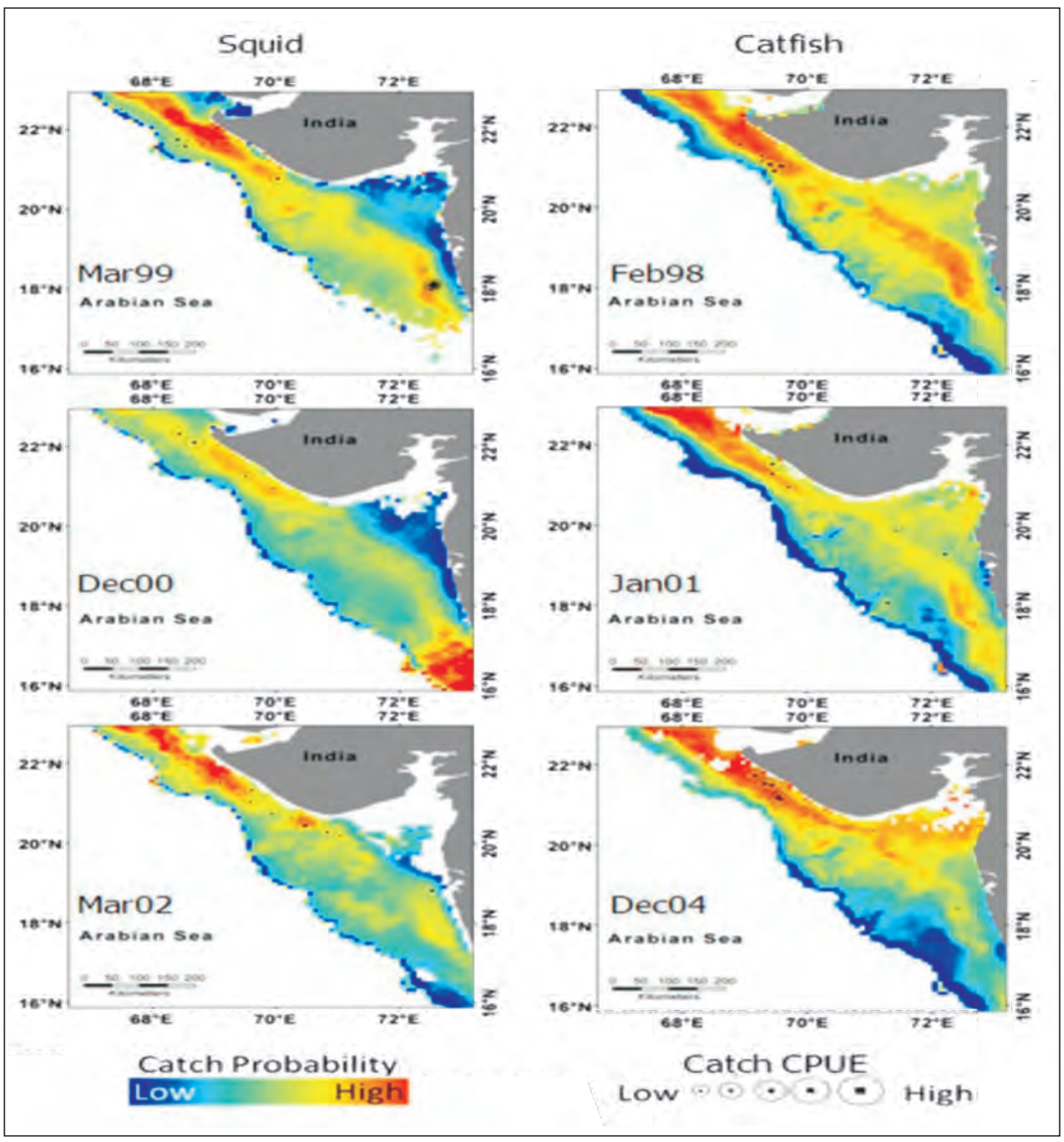
Apart from predicting El-Nino, a detailed research was conducted on enhancement of cyclones over Bay of Bengal (BoB) during the La-Nina events. Several satellite products were used to study the mechanism of ocean dynamics that transports warm western Pacific heat into BoB during La-nina years thereby enhances the cyclonic activities. Further detailed study was performed on Ocean thermal fronts using high resolution GHRSST and INSAT-3D SST products.

Marine Biology and Ocean Colour

To address the emerging and challenging areas in the field of ocean colour, several projects were proposed under ISRO, MOP-III (Meteorological and Oceanography) programme.

Simulated Annealing (SA) and Levenberg Marquardt (LM) techniques were used to estimate chlorophyll-a concentration from remote sensing reflectances. Various ratios based and analytical algorithms were evaluated to retrieve CDOM absorption in Indian coastal waters. Optimized Quasi-Analytical algorithm was observed to perform best to retrieve CDOM absorption. Region specific nitrate algorithm was fine-tuned with the inclusion of salinity as a parameter apart from SST and chlorophyll to generate sea surface nitrate maps of coastal Bay of Bengal. Habitat index map for catfish and squids were generated in GIS using OCM2 data and a generalized additive model. Habitat maps indicated the probability of high catch of

catfish and squids in the continental shelf –slope waters off Gujarat. Intensive sea –truth data collection campaign was carried out in Chilika lake and coastal waters off Gujarat during the ISRO-NASA AVIRIS-NG airborne hyperspectral mission.



Habitat index of squids and catfish using GIS and GAM model

Coral Bleaching Alert Model

Mass Coral Bleaching (MCB) events on a global scale are considered major signals of climate change. Bleaching Threshold (BT) and Positive Anomalies (PA) are two major coral bleaching indices.

Two major coral bleaching indices are, i) Bleaching Threshold (BT) that determines the absolute Sea Surface Temperature at which corals will bleach due to excessive thermal stress and ii) Positive Anomalies (PA) that determines the magnitude of excursion of SST from the Long Term Mean (LTM) of the climatologically warmest month of the coral reef region.

BT and PA indices are computed for five Indian coral reef regions namely: Lakshadweep, Andaman, Nicobar, Gulf of Mannar and Gulf of Kachchh. BT criterion based Coral Bleaching Alert model is developed and run on the global data.

FASAL ACTIVITIES

Estimation of mustard sowing date using INSAT 3A CCDT

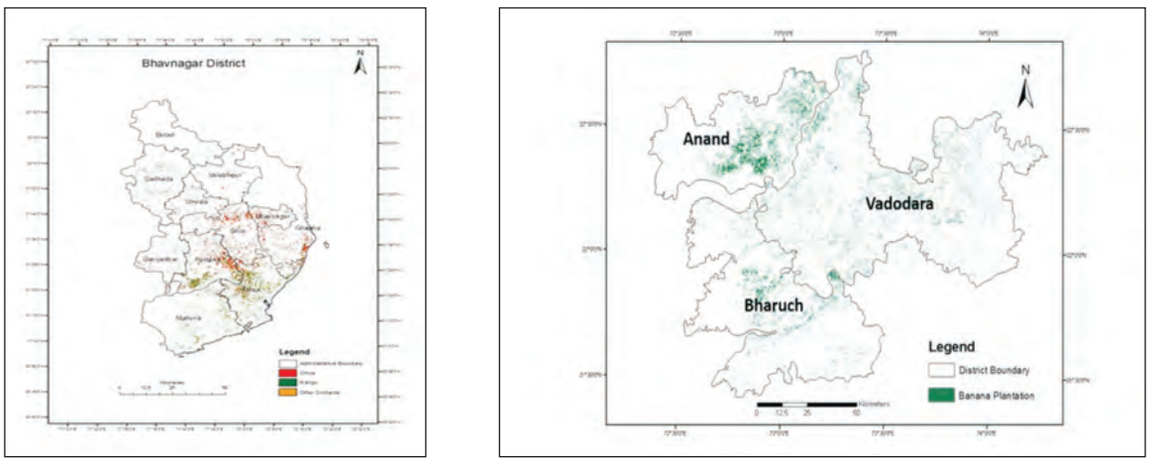
The mustard sowing date is estimated using 7-day composite time series data of INSAT 3A CCD NDVI from 1 August to 31 December, 2015 in six dominant mustard growing states of India viz. Haryana, Rajasthan, Gujarat, Madhya Pradesh, Uttar Pradesh and West Bengal.

Crop Yield Modeling- FASAL

Pre-harvest crop yield forecast at district and state-level has been standardized and operationalized wheat and mustard during rabi 2015-16 using a light-use efficiency based model called Vegetation Photosynthesis Model (VPM) driven by the inputs from polar orbiting and geostationary satellites. Potential primary productivity was computed as the product of light use efficiency and total absorbed photosynthetic radiation. Results indicated good agreement with the reported yield at state level with an absolute difference of around 5 % in mustard and wheat at state level.

CHAMAN: Horticultural Crop Inventory

The mango, citrus and banana orchard inventories were prepared for several districts of Gujarat, Madhya Pradesh, Uttar Pradesh and Bihar states using Resourcesat-2 LISS-IV data and object-based classification. Overall, classification accuracy is found to be 65 to 74%.



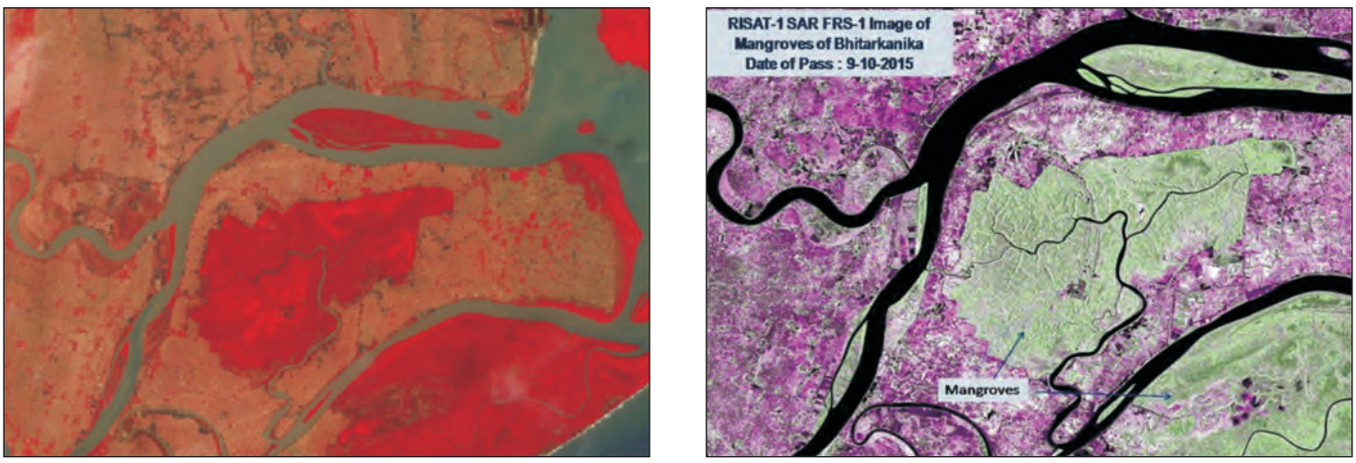
Classified Mango, citrus and Banana orchards for districts of Gujarat

Alpine ecosystem dynamics & impact of climate change in Indian Himalaya

The Himalayan Alpine Dynamics Research Initiative (HIMADRI) network has been successfully established in five Himalayan states of India namely Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh with interdisciplinary and multi-institutional support. The alpine ecotones are being studied for its varying treeline positions in three to four decades. The digital atlas of alpine treeline for the Sikkim and Himachal Pradesh is completed.

Mangrove Characterization

IRS Resourcesat-2 LISS IV data of 21 April 2015 and RISAT MRS data of 09 Oct 2015 were used to classify vegetation type in mangrove forest of Bhitarkanika national park region (Odisha). Optical and microwave data are synergistically used to discriminate 9 different vegetation types using maximum likelihood classification method. Overall accuracy was found more than 80.05 % with Kappa value of 0.764.



Optical and microwave data used in the study

Energy and Mass Exchange in Vegetative Systems under ISRO Global Biosphere Programme (ISRO GBP)

Under ISRO GBP studies are carried out in the following areas:

- Understanding Atmospheric Trace Gases Variabilities & their Environmental Impacts
- Evapotranspiration for agricultural drought characterization though aridity index using Kalpana-1 and INSAT 3A CCD data
- Forest fire detection and monitoring using MIR band of INSAT 3D imager data
- Heatwave detection and analysis using Kalpana-1 VHRR derived land surface temperature (LST)
- Solar energy potential of India using insolation data at 8 km spatial resolution from Kalpana-1
- Conducted AVIRIS-NG Science Campaign across 57 thematic sites where more than 200 researchers from ISRO and non-ISRO institutes participated
- Study on SMAP Soil moisture CAL-VAL using RISAT -1 HH time series data to generate global mosaics of brightness temperature in H and V polarization

Geosciences

Modelling Coastal Sediment Transport and its Impact on Coastal Environment

Developed techniques to estimate total suspended sediment load using OCM data for diverse coastal environment. Long term shoreline change predictions are carried out for selected coastal regions using shoreline delineated using LISS-IV data.

Marine Lithospheric Studies using satellite derived geoid and gravity data

A detailed study on isostasy of seamounts and mid-oceanic ridges of the western Indian Ocean has been carried out using satellite gravity ship borne geophysical data sets.

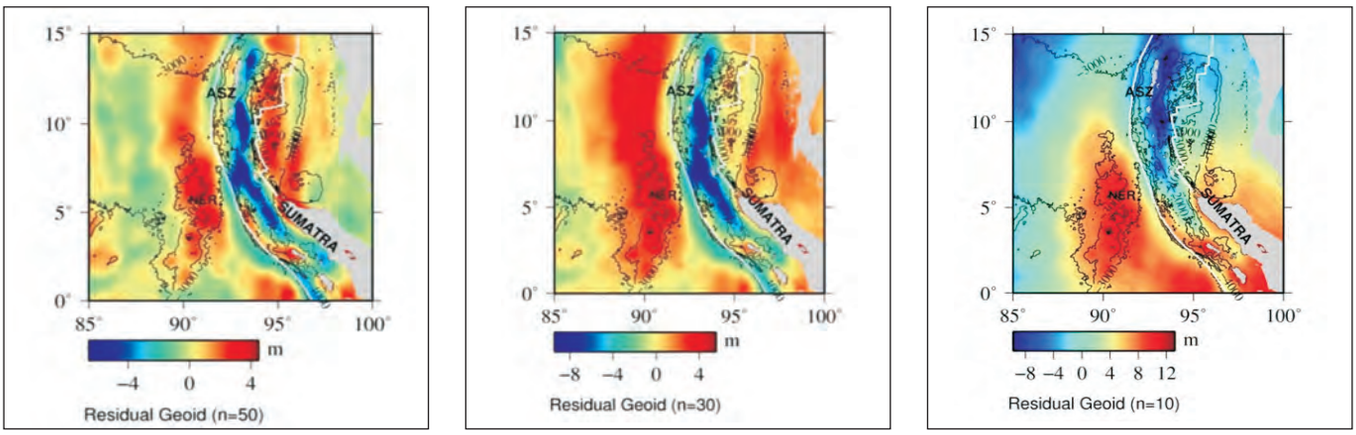


Figure: Residual geoid anomalies of the Andaman Subduction zone region depicting mass anomalies from different depth levels (125 km (n=50), 220 km (n=30), 700 km (n=10)).

Integrated Coastal Zone Management

Coastal thematic maps were prepared and ground truth data was collected for selected parts of Gujarat, Karnataka, Tamilnadu and Odisha coast.

Shoreline Change Atlas of the Indian Coast

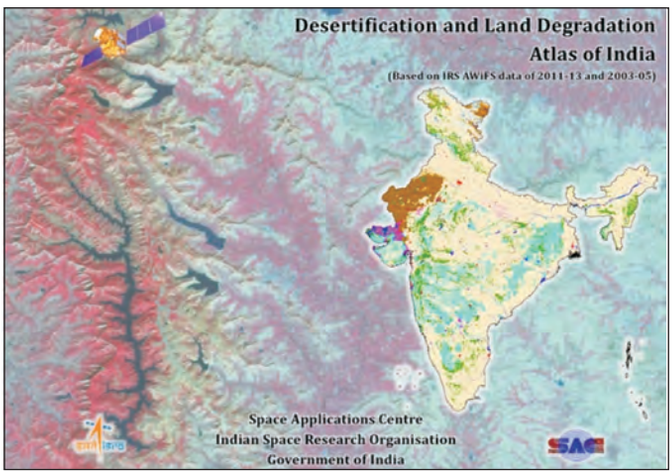
Shoreline change maps of Karnataka and Kerala coast on 1:25, 000 scale using LISS-IV data of 2014-16 in GIS environment is updated.

Shoreline changes mapped using LISS-IV images for the time frame 2014-16 and 2004-06 along parts of Karwar coast, Karnataka.

Desertification Status Mapping of India

Desertification/Land Degradation Status Mapping in GIS environment on 1:500, 000 scale using AWIFS data of 2011-13 and 2003-05 time frames is completed for entire country including change detection.

Preparation of Desertification Status Maps at 1:50,000 scale for 48 districts (Selected Target 78 vulnerable districts of the country) using LISS-III data for 2011-13 and 2003-05 time frames is completed in GIS environment. Desertification/land degradation vulnerability modeling is in progress for 17 districts out of 30 selected districts.



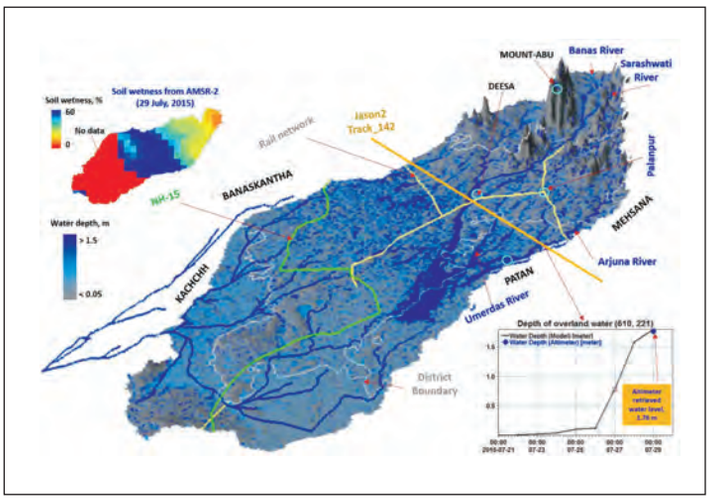
Desertification and Land Degradation Atlas of India

Earthquake Precursors

Crustal deformation associated with major earthquakes of the Indian subcontinent were studied using InSAR and GPS technique.

Land Hydrological Studies

Flood: Inundation simulations for hilly regions of North Gujarat and Rajasthan borders were done using the hybrid technique. Water level estimation in river Ganga, Godavari, Brahmaputa, Gandak, Kosi, Yamuna, Son and Ghaghra using SARAl Altika is carried out regularly.



Simulation of north Gujarat flood using satellite information and hydrological model

Hydrological Drought: A detailed study on Ukai reservoir reveals lowest water levels in 2016 as compared to previous years. The amount of water volume availability was found to be less by 19.8% in the current year (April 2016) as compared to last year (April 2015) whereas it is 88.5% less in comparison to 2014 for the same time frame over the Ukai Reservoir.

Effects of Depleting Ground Water: Over exploitation of ground water in the recent past is well known fact in the Punjab and Haryana region and has been reported by several studies using the satellite based gravity anomaly from GRACE mission and also using observed data. This decline in groundwater has enforced change in the rice irrigation practices over the study region. A study based on Multi-year passive microwave (AMSR-E) soil wetness analysis showed an overall 18-20 days delay (152 Julian day to 172 Julian day) in irrigation practices (in absence of rainfall) in the Punjab and Haryana during 2002 to 2011.

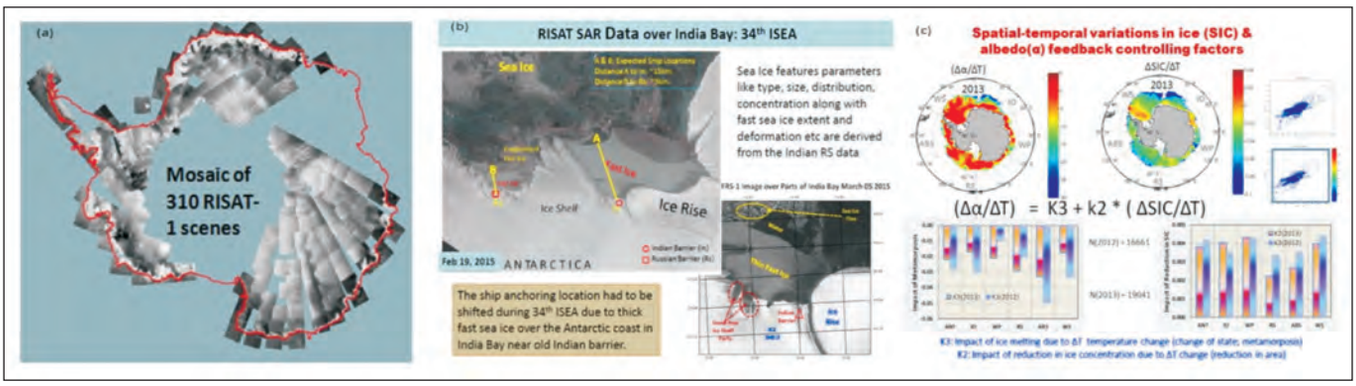
Cryosphere Sciences

Monitoring Snow and Glaciers of Himalayan Region

The project on Monitoring Snow and Glaciers of Himalayan Region with Ministry of Environment, Forests and Climate Change (MoEF&CC) is successfully completed. Geospatial database of 5 and 10 daily sub-basin wise snow cover maps are generated using IRS AWiFS data and NDSI approach for 35 sub-basins of the Indus, the Chenab, the Satluj, the Ganga, the Tista & the Brahmaputra river basins and glacier inventory data covering 75, 779 sq km area. In addition, Snow cover results have been compiled in 42 Snow Cover Atlases providing basin/sub-basin wise information on snow cover extent, area statistics and time sequential analysis. A Himalayan Glacier Information System is developed.

Polar Region

RISAT-1 CRS mosaic of the Antarctica using more than 300 scenes covering the major parts of Antarctica was prepared. The visual analysis of the mosaic led to detection of an uncharted ice berg that had disintegrated from the ice shelf nearby India Bay, Antarctica.


(a)
Mosaic of 310 RISAT-1 scenes
(b)
RISAT SAR Data over India Bay: 34th ISEA
Sea Ice
Ice Shelf
Ice Rise
Feb 19, 2015 ANTARCTICA
Sea Ice features parameters like type, size, distribution, concentration along with fast sea ice extent and deformation etc are derived from the Indian RS data
The ship anchoring location had to be shifted during 34th ISEA due to thick fast sea ice over the Antarctic coast in India Bay near old Indian barrier.
(c)
Spatial-temporal variations in ice (SIC) & albedo(α) feedback controlling factors
(Δα/ΔT) = K3 + k2 * (ΔSIC/ΔT)

(a) RISAT-1 Mosaic of Antarctic terrain; (b) an example showing output provided for safer ship navigation during Antarctic expedition and (c) inter-annual variations observed in the sea ice sectors for the ice-albedo feedback controlling factors.

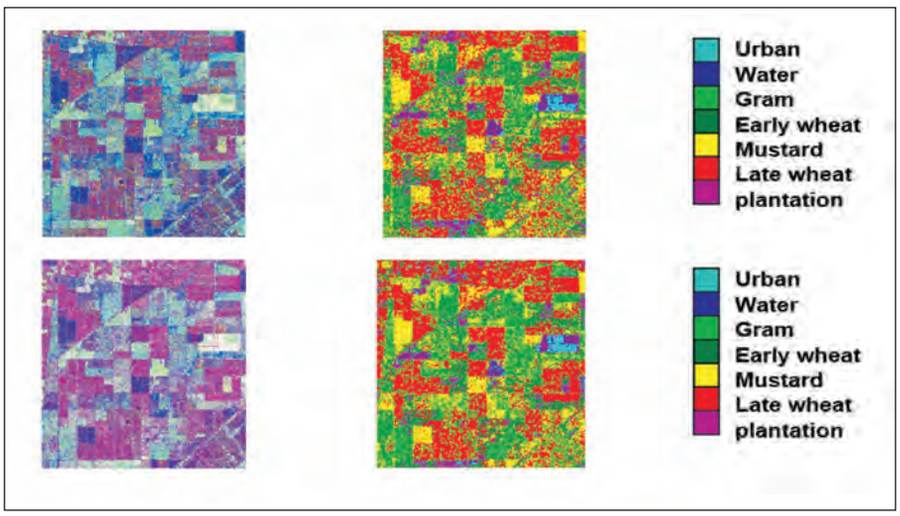
Ice velocity for "Polar Record" glacier, Antarctica was derived using RISAT-1 MRS data (2013 & 2015). SAC team participated in the 35th Scientific Expedition to Antarctica.

SAR Data Analysis Technique Development and Applications

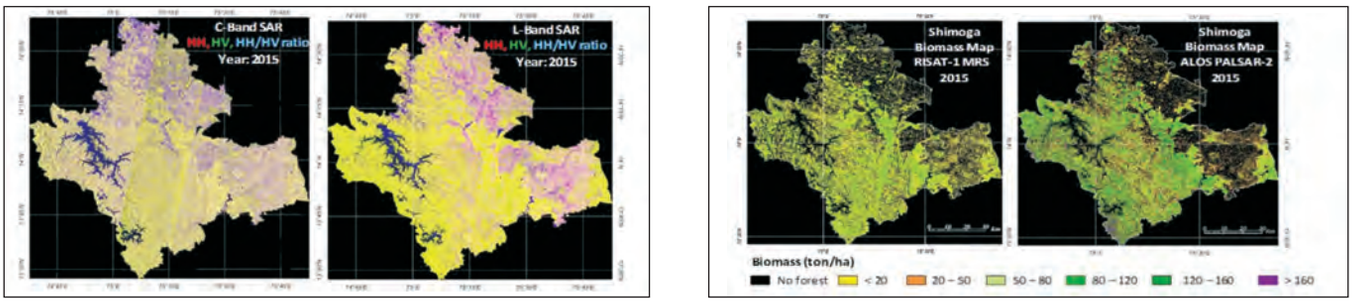
Agriculture: Land cover classification was carried out over vegetated areas using RISAT-1 Hybrid Polarimetry data with indigenously developed Polarimetric processing tool and GUI.

Acreage estimation of cotton crop for Kharif season of 2015 using RISAT-1 MRS and FRS data was carried out. Technique is developed for high resolution backscattering coefficient using OSCAT data for crop phenology.

Forestry: Estimation for forest above-ground biomass of Shimoga, Karnataka using SAR data: Forest above-ground biomass of Shimoga district, Karnataka was estimated using RISAT-1 and ALOS-2 PALSAR-2 data. The biomass retrieval models for C-band and L-band were developed.



Discrimination of land cover classes over vegetated area using M delta and M Chi decomposition RISAT hybrid polarimetry



(Top) - RGB images generated from C-band (RISAT-1 MRS) and L-band (ALOS-2 PALSAR-2) SAR data of Shimoga district (Karnataka); (Bottom) - Forest above-ground biomass maps of Shimoga district generated using RISAT-1 MRS data and ALOS-2 PALSAR-2 data of the year 2015.

Soil Moisture Retrieval: Vector Radiative Transfer (VRT) model was developed and validated for bare and crop (Winter wheat) covered soil using time series RISAT-1 MRS data with ground truth data. Developed and validated an ANN based inversion methods for Soil moisture and surface roughness from RISAT-1 data. A processing scheme and a GUI based Module is developed to generate Global and Indian mosaic of brightness temperature (Tb) and derived products using L-band SMAP radiometer data products.

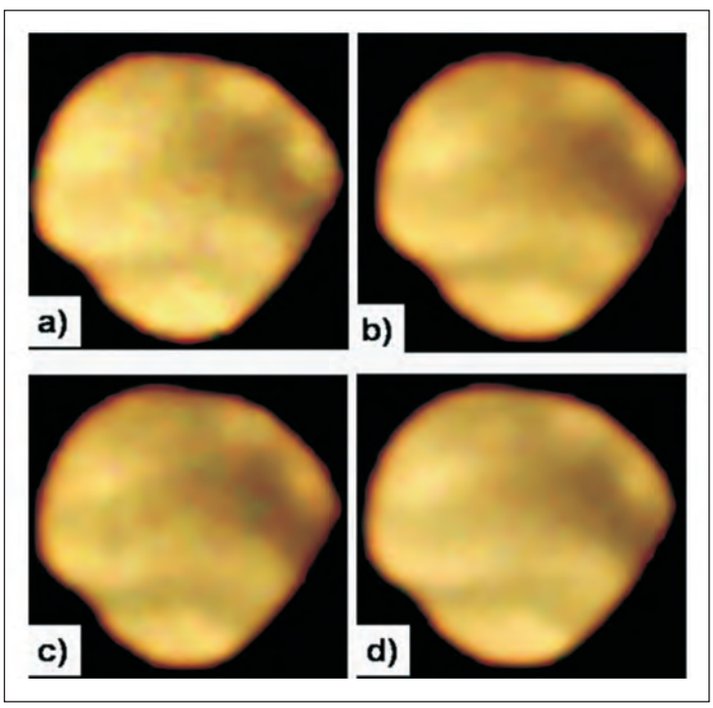
Glaciers: Changes in glacial facies for Durung Drung, Chhota Shigri, Gangotri and Zemu glaciers were studied using RISAT-1 MRS data for the year 2012-2015. Glacier mass balance was also estimated based on estimation of Equilibrium Line Altitude (ELAs) and Accumulation Area Ratio (AAR) approach.

Fog Detection using satellite data

A new temporally continuous fog detection technique using visible, MIR, TIR1 and WV channels of INSAT-3D imager was developed and validated against visibility data for 2013-2014 winter months over India.

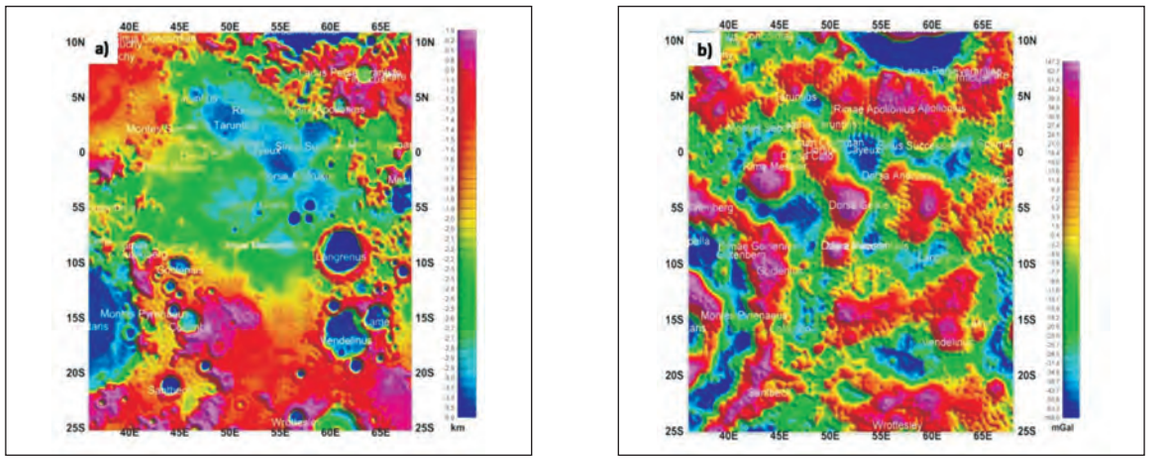
Planetary Sciences

Imaging of Farside of Deimos: Mars Color Camera (MCC), onboard Mars Orbiter Mission (MOM) acquired four image-frames of far side of the Deimos, the farthest of two natural satellites of Mars, on October 14, 2014 at around 13:05 UT. Mars and Deimos are tidally locked so one would always get to view the same side of Deimos from Mars. Most of the contemporary functional satellites orbiting Mars viz. Mars Reconnaissance Orbiter, Mars Express, Mars Odyssey, MAVEN etc. are positioned between Mars and Deimos, hence they always view only one side of Deimos i.e the Mars-side, while the far-side is always looking outward with respect to all these satellites. However MOM is an exception as it has a very large elliptical orbit and goes behind Deimos orbit. This has enabled MOM to view the rare far-side of Deimos which has not been viewed for last few decades by any Mars orbiter.



Four frames of Deimos captured by Mars Color Camera (MCC)

Lunar gravity studies: Lunar Freeair and Bouguer gravity anomalies are computed using recent high resolution gravity models (GRAIL-420A, 660B, and 900C) of NASA's GRAIL mission. Detailed interpretation of Lunar gravity anomalies, integrated with morphological mapping using Lunar Reconnaissance Orbiter Wide Angle Camera (LRO-WAC) data sets is carried out for understanding evolution of Mare Fecunditatis and selected basins of Farside. Plausible deep seated subsurface structures are detected from preliminary interpretation of Freeair and Bouguer gravity anomalies, topography and geoid over Mare Fecunditatis and adjoining regions of Mare smythii.



a) Topography b) High pass filtered Bouguer gravity anomaly maps of Mare Fecunditatis and adjoining regions of Moon.

Discovery of endogenic water on the Moon: High-resolution spectral and spatial data analyses of crater Theophilus revealed the presence of hydroxyl-bearing exposures of possible magmatic origin on its central peak in association with olivine, spinel and crystalline plagioclase-bearing lithologies. Hydroxyl-bearing lithologies at Theophilus central peak are characterized primarily by a prominent absorption feature near 2800 nm, the strength of which varies from 2% to 6% in some localized zones within the central peak. The strong and sharp 2800-nm hydroxyl feature having localized occurrences on the central peak of crater Theophilus is inconsistent with a surficial origin. It is thus concluded that the observed hydration at Theophilus central peak could possibly be associated with a sub-crustal magmatic source that was subsequently tapped and exposed by Theophilus impact event.

Study of aqueous minerals from the Capri Chasma region of Valles Marineris on Mars: Spectral reflectance data from the Mars Reconnaissance Orbiter-Compact Reconnaissance Imaging Spectrometer for Mars (MRO-CRISM) of Capri Chasma, a large canyon within Valles Marineris on Mars, is studied. Results of this analysis reveal the presence of minerals, such as, phyllosilicates (smectite: montmorillonite) and carbonates (ankerite). These minerals hint of the aqueous history of Noachian time on Mars.

MOSDAC

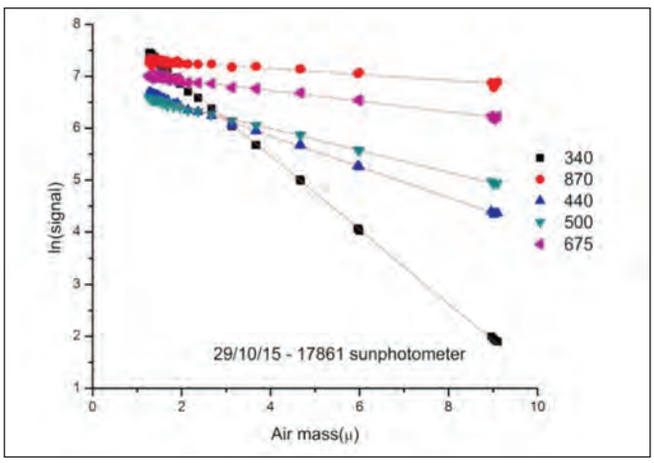
The Meteorological and Oceanographic Satellite Data Archival Centre (MOSDAC) completes a decade of service to the nation. MOSDAC is a storehouse for space based weather and ocean data from missions such as INSAT-3A, KALPANA-1, INSAT-3D, MEGHATROPIQUES, SARAL, OCEANSAT-II. This data is disseminated on the web site in near real time. New data products added this year are Rain Rate from SAPHIR sensor of MeghaTropiques, SARAL coastal data products covering Gujarat Coast, INSAT3D Cloud Microphysics product and INSAT3D IMC product (high resolution rain). New Science products introduced in the web site as open data (free access) are (i) Satellite Altimetry derived discharge over Godavari River during 2002-2015 and (ii) Wave Power (potential renewable energy resource available from ocean waves over Indian Ocean region) (iii) Ocean Surface Currents (iv) Sea Ice advisory for 35th and 36th Indian Scientific expedition (v) Drifting of Antarctic Iceberg (vi) Sea Ice Occurrence Probability and (vii)

Inland Water Height. MOSDAC along with SAC library has implemented Digital Object Identifiers (DOI) based Persistent Identifiers for Data products.

MOSDAC has adopted Content management system and migrated to the next generation web infrastructure. MOSDAC's presence on Facebook and Wikipedia is established.

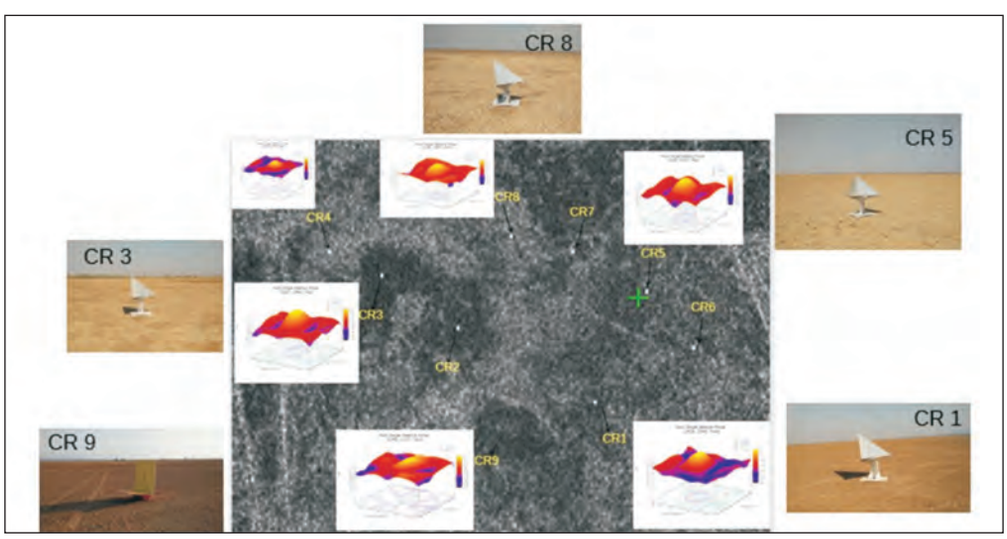
Calibration and Validation

Sun-photometer calibration carried out during 28-30 October 2015 using Langley Plot technique at high altitude site; Mt. Abu PRL observatory was found to be the most suitable place for such an exercise with less than 2.5% variability on Aerosol optical depth over a period of three cloud free days.



Langley plot for sun-photometer

Absolute calibration and image quality assessment of RISAT-1 FRS-1 and MRS data was performed for twelve synchronized overhead pass over Desalpar, Rann of Kutchh(Gujarat) and Ahmedabad sites spanning eleven months from April 2015 to February 2016. Point targets(Corner reflectors of different shapes and sizes viz. dihedral, square trihedral and triangular trihedral having 1.5m, 0.60m and 0.90m leg length respectively) as well as distributed target(Amazon forest) data were used for absolute radiometric calibration. Initial calibration analysis revealed that the difference between the average estimated calibration constants and the constants provided with the data was found to be within 1 dB for both MRS and FRS mode data.



Impulse Response function, field photographs and response of the deployed Corner Reflectors as seen in RISAT MRS Image of 10th March 2016.

Visualisation of Earth Observation Data and Archival System (VEDAS)

SAC is responsible for carrying out research and applications of optical and microwave remote sensing data in a large number of disciplines including Agriculture, Landuse, Photogrammetry etc. VEDAS infrastructure will help towards operationalization of spatial infrastructure, information dissemination system and training & research platform.

Some of the salient features are as follows :

- Providing platform for Research & training to Academia by providing data, domain knowledge and infrastructure
- Satellite based geo-spatial data Archival and Dissemination
- Data visualisation and graphical analysis on web
- Spatial and Non-spatial search engine
- Publish Web map services and metadata of all data
- Geo-processing tools for analysis
- Mentoring development of Indigenous map server software (IGIS Server)
- Integrate Web Map Service from various sources including Bhuvan& NRDB

A training center with computers and related software has been operational for researchers and students at Bopal campus of SAC.

VEDAS Home page

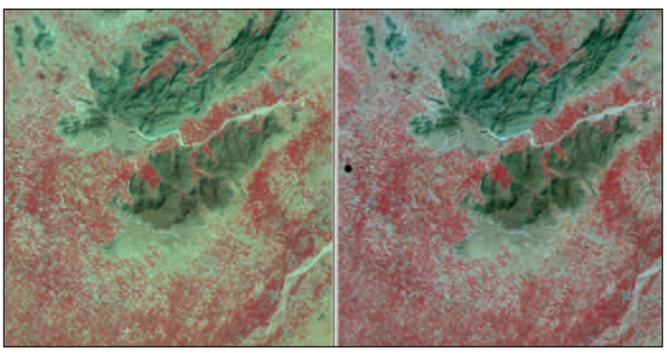
Flag-ff function of Cartosat 2C

Remote Sensing Data
Products

Data processing activities at SAC encompasses every optical and microwave remote sensing missions bound for earth and planetary bodies. Resourcesat, Cartosat, Oceansat, RISAT, Airborne platform sensors data processing system generate different levels of correction applied products used for resource monitoring and mapping applications for land and ocean.

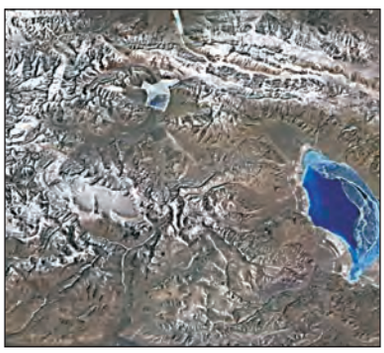
RESOURCESAT-2 DP operational at IMGEOS facility

Image restoration, destriping and denoising algorithms and software development is completed. Tested and validated 6S based atmospheric correction for LISS-3 and AWIFS data sets using MODIS data derived values. Optional topographic correction approaches and software modules are developed and provided test version of these software modules to IMGEOS.



RS-2 AWIFS ATCOR Validation with MODIS

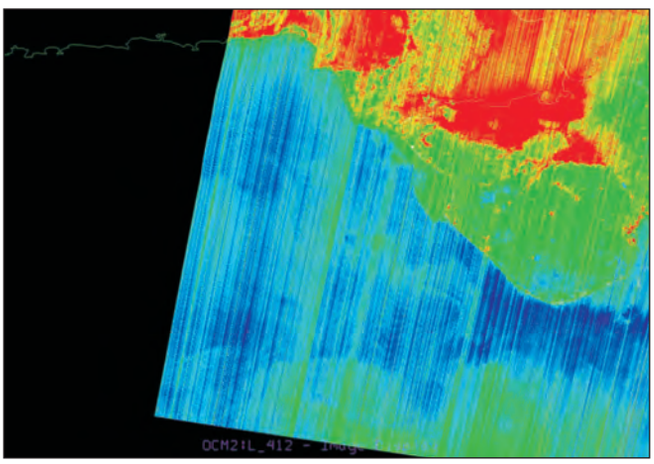
LISS3 Full Strip Processing



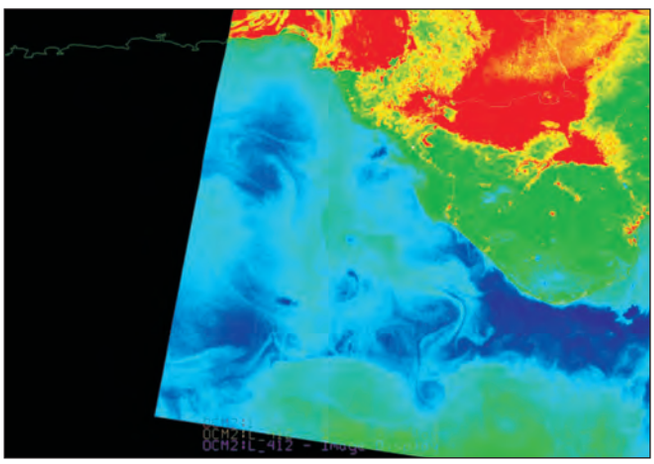
AWIFS topo Correction

OCM-2 Data Processing (2015-16)

In OCM-2 DP, Radiometric lookup tables are revised which is based on LAB LTC data. Revised Atmospheric Correction Model was incorporated in the Level-2 Product Generation. The Total Variation (TV) based adaptable de-striping approach was developed for removing stripes at Level-1 Rad Product and Level-2 Water Leaving Radiance Level. Updated Software was provided to NRSC, Hyderabad. Level-2 Software was made configurable in terms of the coefficients used for Level-2 Parameter Retrieval Algorithms. IGS installation for OCM-2 DP was carried out at EuroMap, Germany in Nov 2015.



TOA 412 nm(Original)



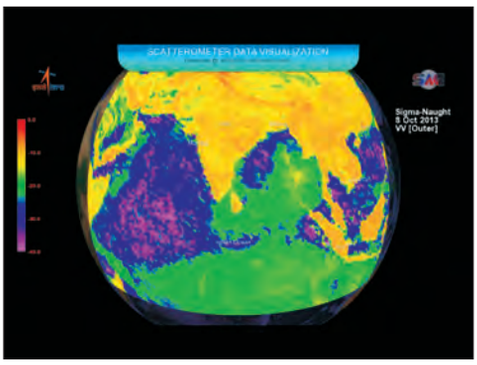
TOA 412 nm (Destriped)

Cartosat-2C

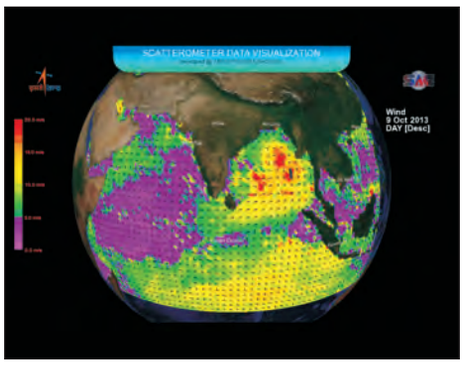
Critical Design Review of Ground Segment is completed and internal Test and Evaluation is conducted. One session of external Test and Evaluation is performed at NRSC. This includes integration of all ground segment elements including Level-0, SAC DP and DQE and NRSC elements which define the entire workflow for product generation. The software packages are installed for processing real data at NRSC. It is will be fully qualified for performing pre-launch simulations, processing first day data and for operations once the second T&E is over.

Scatterometer DP

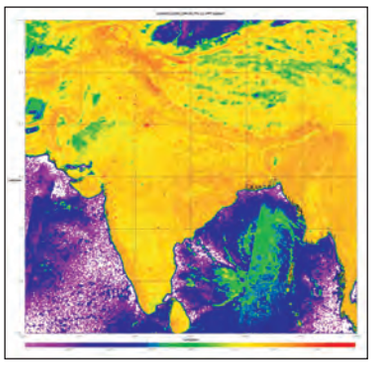
Software components are developed and integrated for simultaneous 50 km and 25 km product generation for SCATSAT-1 Data Products in IMGEOS environment at NRSC-Shadnagar. Raw mode processor are developed in order to handle programmable S+N, Noise-only start positions & samples' pickup, variable frame lengths within processed frame, larger data volumes and pre-Fdc/ post-Fdc compensation. Improvements in turn-around time is achieved by multi-threading at process level for L1B and L2A products. A software package is developed for analysis of Level-0 data and products which will enable to provide quick feedback in initial phase and automated reports in operational phase. A Windows-based software package is developed for dynamic visualization of wind products. The Scatterometer Image Reconstruction (SIR) algorithm is developed for higher spatial resolution of data.



Sigma-0 visualization



Wind visualization



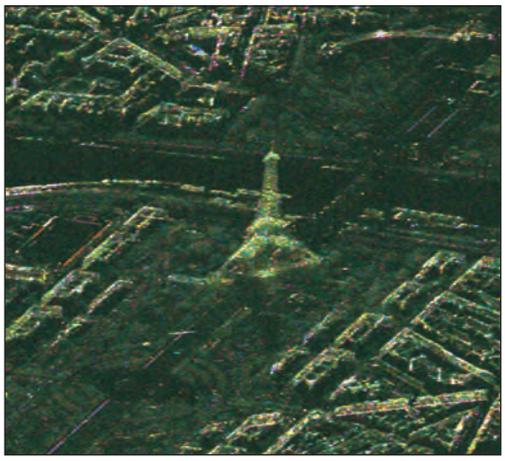
High-Resolution L1B product over Indian region

RISAT-1 DP

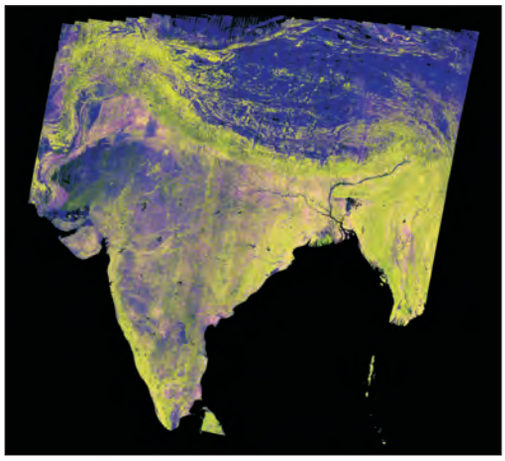
RISAT-1 DP software was augmented for handling the data product generation for along track shift in scene. Enhanced Georeferenced product (Level - 2A) was introduced to improve the geolocation accuracy. Local incidence Angle map & layover/foreshortening mask was provided along with the product. Software for L2A product generation was parallelized for improving the turn-around time.

A novel data processing algorithm was developed and implemented for processing HRS data. All acquisitions of HRS were processed. Resolution of better than 1 meter was achieved in both range and azimuth directions. Software for polarimetric processing of HRS data was developed. Full 100 Km mosaics were generated for all the acquisitions.

A full MRS systematic cycle data was processed. A full India Gamma0 & Sigma0 Mosaic product was generated. The scenes were mosaiced based on the concept of filling 1 degree x 1 degree tiles in Geographic Latitude Longitude. Left to right direction was adopted when sidelap areas were considered, i.e. the overlapping area of left scene and right side scene were blended. In the top-bottom direction, overlapping region were filled from the top scene. The pixel spacing of the data was retained at 18 m. The mosaic is put in VEDAS site as a layer.



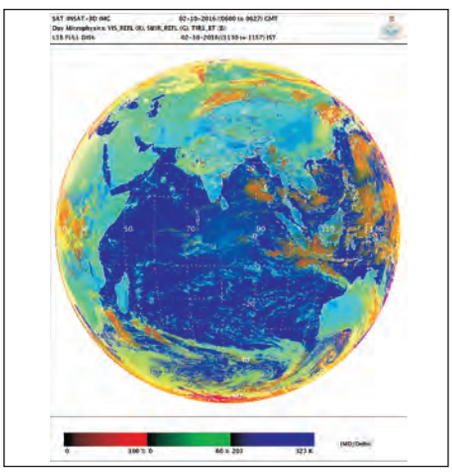
HRS mode Eiffel Tower, Paris



Full India MRS Gamma0 Mosaic

INSAT DP (IMDPS) & Special Products Software

IMDPS products are improved for both geometric and radiometric quality. The improvement in navigation accuracy was achieved by Fixed Grid Navigation and Automatic Template Based Feature based Registration (using SIFT and SURF based approach) package for INSAT-3D Imager. The sounder data processing software was made robust to handle zero attitude situation by introducing closed loop automated template based registration. The Imager data processing software was enhanced by doing ground based Mirror Compensation Data (MCD) based correction for all the channels. Augmented data products with Atmospheric correction and Topographic correction for Visible (VIS) and Short Wave Infrared (SWIR) channels. Incorporated residual coefficients in Global Space-based Inter-Calibration System (GSICS) to improve radiometric calibration of Imager and Sounder. Improved Imager Product radiometric quality by implementing offset correction technique based on improvised moment matching for removal of horizontal striping / banding from MIR and TIR-1 & 2 channel of IMAGER.

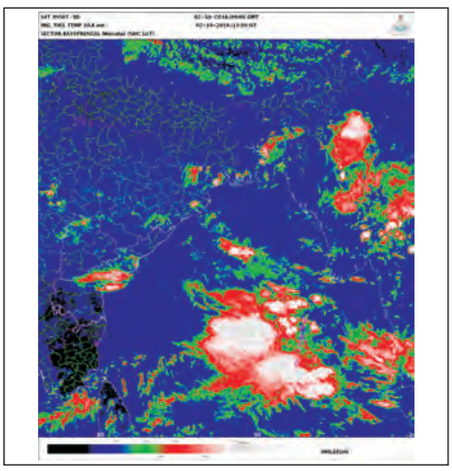


Imager Full Globe Day Micro-Physics FCC Product R(VISReflectance), G(SWIR Reflectance), B(TIR1 BT)

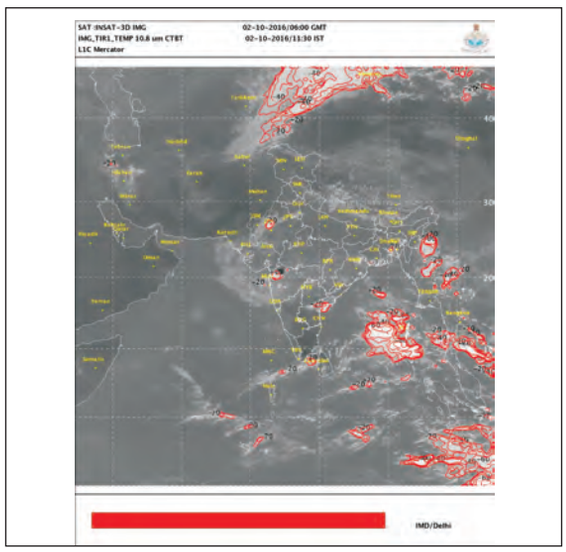
Heatwave products using Thermal Infrared bands are generated daily and posted in MOSDAC. FCC Day Micro-Physics, High resolution sector with district boundary, Cloud Top Brightness Temperature (CTBT) with contour, Sector with BRT LUT, Binned daily Insolation and Potential Evapo-transpiration (PET) and RGB composite of Sounder air mass imager products are added.

The Ancillary Data Products Generation Software (ADPS) was modified to include AWS to GTS conversion capability, as well as GTS decoding and archival mechanism. New products such as Satellite Aided Nowcasting Product using INSAT-3D Imager TIR1 Band based on FORTRAC algorithm and improved IMSRA Product Generation are added to the scheduler.

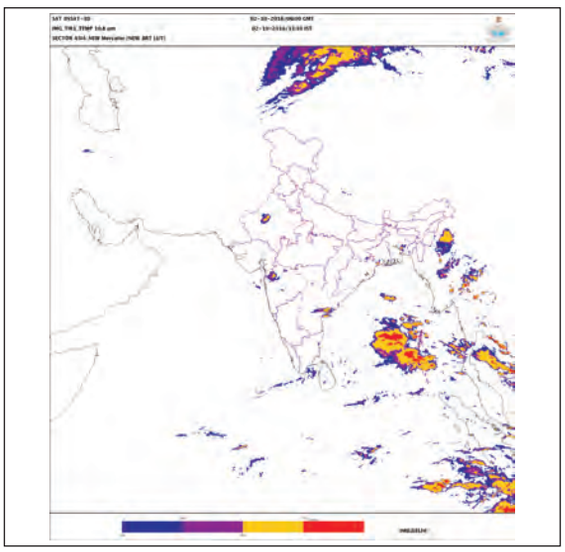
Report and chart generation capabilities are incorporated to ADPS. AWS and GTS point data visualization and RGB composite images animation capabilities are added to RAPID.



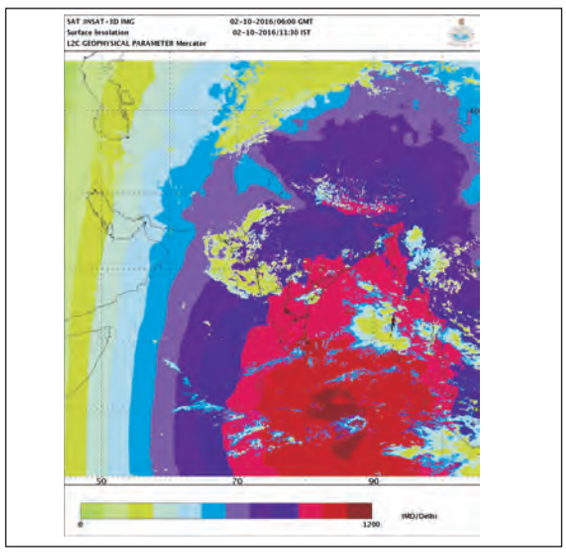
High Resolution Sector Product with NHC LUT along with district Boundary



Sector Product With CTBT
(Cloud Top Brightness Temperature)

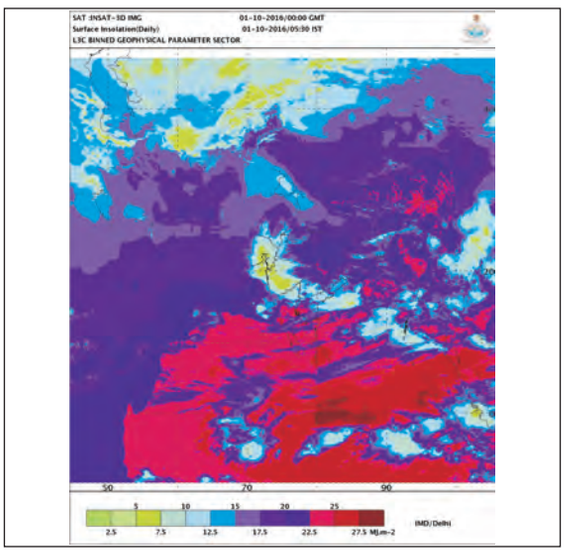


Sector Product with New BRT LUT

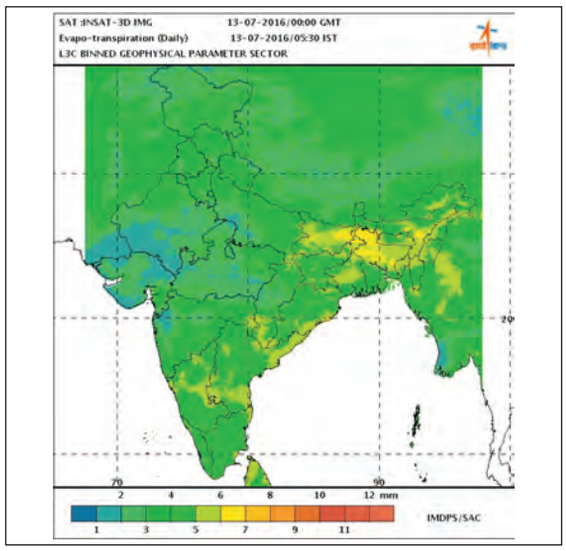


Instantaneous

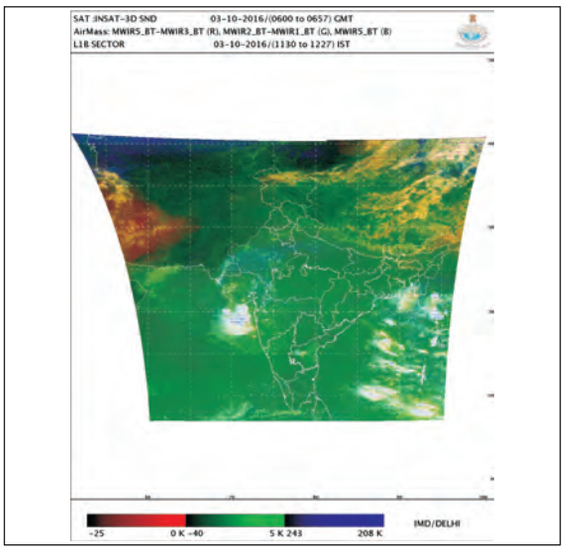
INSOLATION



Daily



Imager :Daily PET (Potential Evapo-transpiration)



Sounder : RGB Composite Airmass

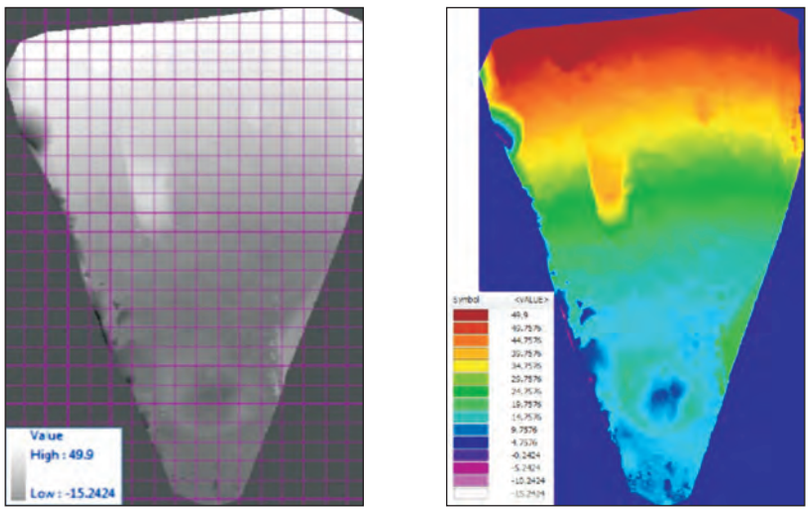
Chandrayaan-2 DP

Lander HDA System: Developed robust algorithms for crater detection and crater catalogue development for Hazard Detection and Avoidance (HDA) system.

DEM Generation from NavCam Stereo Images for Chandrayaan-2 Rover traversal: Methodology for DEM generation from stereo NavCam images is developed. Direct Linear Transformation (DLT) based approach is used for camera calibration. The image matching between stereo images is performed using Normalised cross correlation technique and conjugate points are generated automatically.

DEM

Painted DEM



Navcam Images and corresponding generated DEM output (Values are in cm)

Data Analysis of Chandrayaan-2 Rover Imager Camera: Data analysis was mainly focused on qualifying image data quality in terms of MTF, SNR and recommended JPEG compression ratio to be used in on-board camera electronics for different modes. The following studies have been carried out on the datasets acquired from Rover imager.

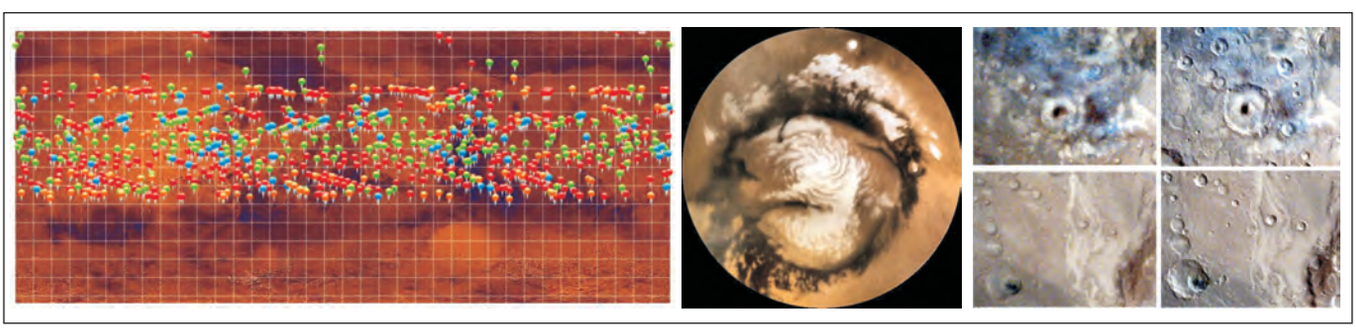
a) MTF study on
   i. Acquired/original and restored images.
   ii. Before, during and after vibration test images.
b) SNR study on acquired outdoor images.
c) Study on different JPEG compression ratios.
d) HDR image generation

Images acquired in indoor and outdoor were used for MTF study and MTF of restored image is compared with original image.

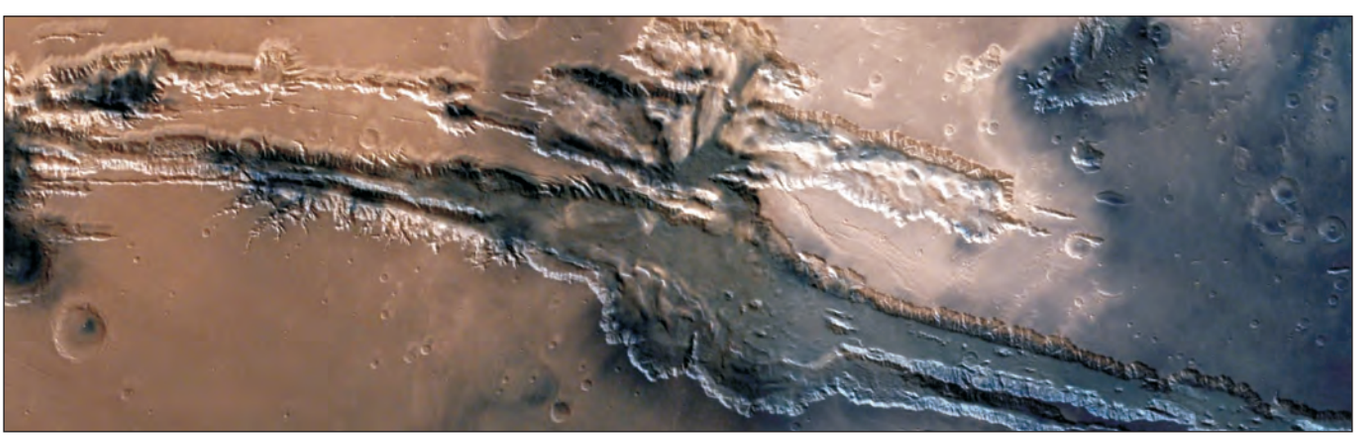
Mars Orbiter Mission DP

Mars Orbiter Mission (MOM) science data processing activities include, transforming telemetry data comprising both primary and ancillary into different levels of science data products processed for radiometry and geometry aspects following established universal standards to incorporate all acquisition, calibration information, processing context details to be archived for long term use. SAC data processing solution deployed at ISSDC and SAC POC processes, MCC, TIS, MSM, LAP and MENCA datasets for the period from 24th September, 2014 to till date are processed, raw and calibrated products are generated for active archive PDS, raw and calibrated products are prepared in long term archive PDS.

MCC PDS data viewer tool was developed and provided along with data sets. Many geometry parameters are computed using MOM SPICE geometry kernels and kept as metadata in the archive. Topo correction procedure was developed for MCC data sets and many outreach products are generated. Deimos coverages are also processed successfully. An ISRO outreach kit was developed and provided to Indian museums with popular information on Mars Orbiter Mission, Remote Sensing etc.



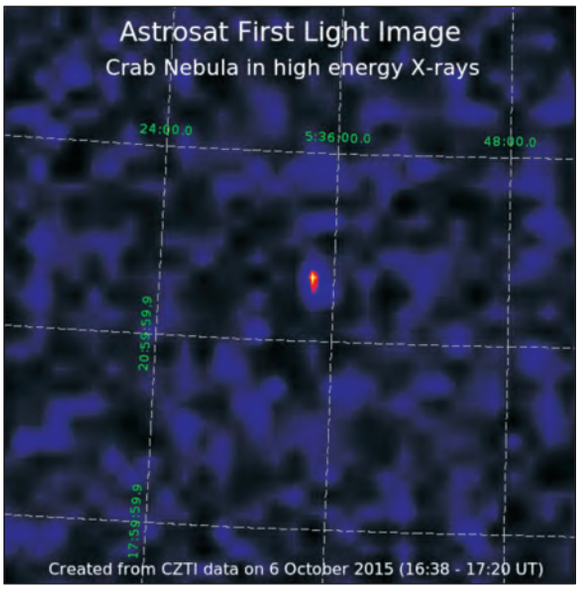
(a) Data sets acquired and processed so far from Mars Orbiter Mission, (b) north pole mosaic (c) photometric corrected data sets



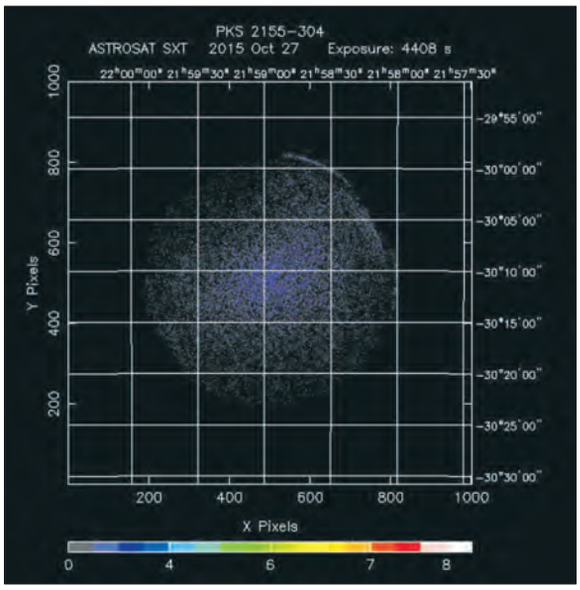
Valles Marineris mosaic covering 4000 km tectonic crack of Mars after color matching

ASTROSAT - DP

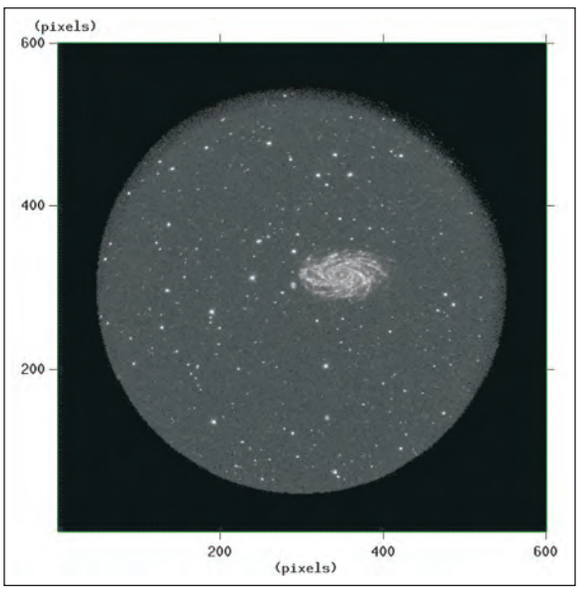
Total 12 packages are developed including Level-2 i.e. Science Data Processing for 4 payloads (CZTI, SXT, UVIT, LAXPC), Quick Look Display for above mentioned instruments as well as Archive, Browse and Dissemination of Level-1 and Level-2 for the data processing of Astrosat. Level-2 software generated important science results which are showcased to international astronomical community through ISRO as well as IUCAA/Astrosat web portal.



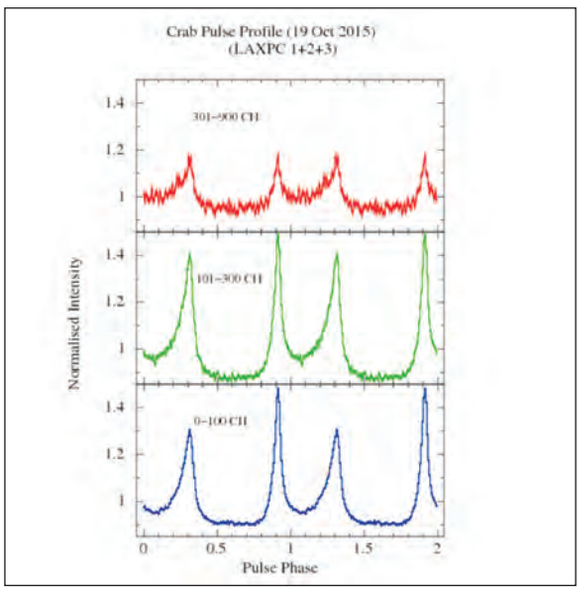
CRAB in High Energy X-Ray from CZTI



PKS2155-304 from SXT



NGC 2336 from UVIT



Combined CRAB Pulse profile from all three LAXPC instruments

Data Quality Evaluation (DQE) systems

Cartosat-2C DQE

Completed design and development of DQE software for Cartosat-2C for new elements; Moon calibration, Calibration using Stellar data, Optical butting region analysis and noise estimation.

ScatSat-1 DQE

Scatsat-1 DQE Software Detailed Design is completed and reviewed. DQE for Scatsat-1 is planned in three independent components. (i) Level-0 DQE to ensure real time monitoring of system behaviour, (ii) Static and Dynamic parameters evaluation from Level-1B scan mode products and Level-2A grid mode products and (iii) Traceability of quality parameters from Level-2A products to Level-0 data. Level-0, Level-1B and Level2A Software in fully automatic mode of operations is ready for Test and Evaluation. Database for

storing metrics, performing detailed analysis and providing linkage between different levels of data is designed.

INSAT-3DR DQE

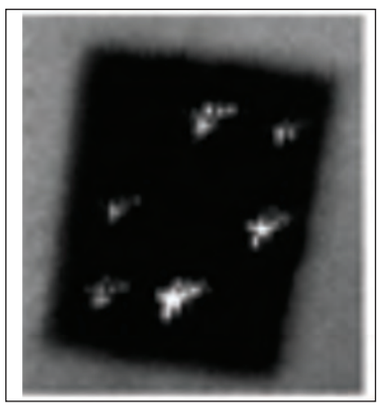
Carried out Lab Data Analysis for Sounder which includes Telemetry, Analysis of VTBS & SRT data for Hot/Cold/Ambient Cycles and Radiance, Temperature Spectral Profile, Noise (counts)@300k Dynamic Range, Saturation.

CAL/VAL

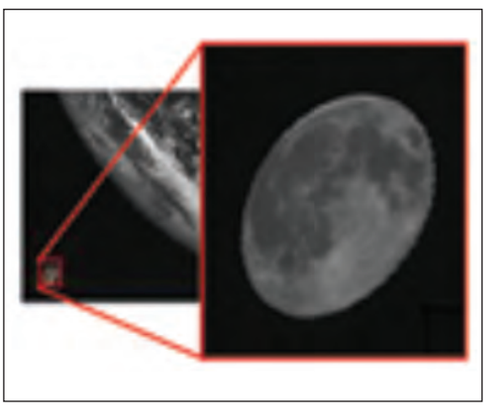
As a part of Cartosat-2C spatial characterization plan, a sensitivity analysis of convex mirror dimension versus sun/sensor viewing geometry was carried out.

Global DEM

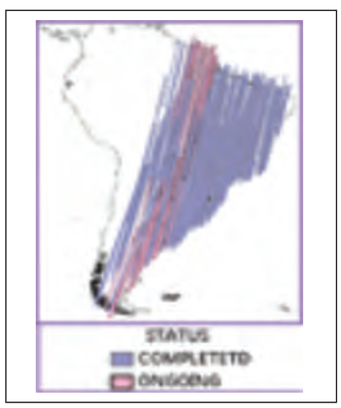
DEM generation and quality assurance and verification is completed for 277 South America datasets (second set) received from NRSC; Pre-processing is in progress for third data set. Cloud marking is completed for 160 segments and GCP marking completed for 89 segments out of 177 segments.



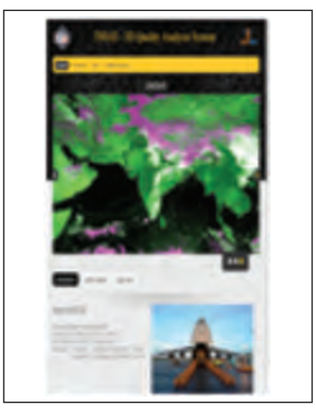
Mirror targets imaged by



Moon in Field-of-Regard of INSAT3D VIS channel



GDEM Status for South America



INSAT-3D Quality Analysis Portal i3dQAS

Facilities

During the year various facilities are established/ augmented to facilitate payload development requirements of the centre. Also, initiated development of various technologies in the field of Electronics and Mechanical requirements of future payloads.

Mechanical Facilities

During the year, more than 45,400 components are made in house and 53,100 are made using External fabrication facilities. Around 500 components are tested in vibration lab.

- Waveguide run Assemblies for WR-75 FM Waveguide developed in House for GSAT-11 project in 200 to 500 mm length.
- First time Heat pipes were developed and embedded in Aluminium Honeycomb panels at SAC workshop.
- Fabrication of components by Direct Metal Laser Sintering (DMLS): Antenna feed horns, Waveguide twist and filter components were developed in INVAR and Aluminum using DMLS technique and Qualified as per approved QA Plan.
- Primary Mirror Baffle Cylinders of ø197x 141/ 158/ 336 Size (mm) is developed for GISAT project.
- 600 mm dia. CFRP Antenna reflector (BBM) is designed and developed first time in house for Space use.
- First ever 7 channel Temperature Compensated Ku Band Output Multiplexer is delivered for GSAT-18 P/L with mass reduction of 40 % and foot print reduction by 50 %.
- Developed S-band helix feed for 6m dia. Unfurlable Antenna of GSAT 6 Project.

Electronics Facilities

During the year a large number of MMICs are designed and delivered. Also delivered number of SAW devices after design, fabrication and test. Low Temperature co-fired Ceramic fab line is space qualified and started delivering circuits and components. Other important activities are thermovac test of satellite payloads, Electronic support, calibration & repair and IT infrastructure development.

- Delivered 2600 FM and 2000 R&D patterned MIC substrates for GSAT-11, 17, 19, INSAT-3DR and Chandrayaan-II etc.
- Delivered 270 Cr-Masks 40 calibration targets for all ongoing projects.
- Hermetic sealing completed for 24 MMIC devices and delivered.
- Delivered 8408 no. of PCBs for Aditya, Astrosat, Cart-3, GISAT, GPR, GSAT-19, 20, Resourcesat-2A, mmwave, HSP, Nanosat, NISAR, GSAT-6.
- 112 Packages were delivered for Cartosat-2C, INSAT-3DR, GSAT-15, 18, IRNSS-1E, IF, 1G, CY-2, Scatsat-1, RS-IIA.
- RF packages delivered 408no., for Delivered in 2015: IRNSS-1F, 1G, INSAT-3DR, Scatsat-1, GSAT-11, GSAT-17, MMW, RISAT, NISAR, MiniSAR, CY-2.
- 23763 hours of thermovac , 71476 hours of climatic test is completed for different projects.
- Surface treatment on 1216786 sq, cm. and thermal painting on 727270 sq. cm. is carried out for different projects
- Calibration and maintenance of test and process equipment – completed for 908 equipment is completed.

- **On Chip Filter Technology – SAW:** Following process are developed and qualified to fabricate SAW devices for space use.
  a. E-beam direct pattern generation using metal left-off technology for 0.75 micron,
  b. Micro sand blasting for pit-generation (depth: 40%) on SAW wafer to supress spurious modes

- **Monolithic Microwave Integrated Circuit (MMIC):** Delivered 200 MMIC die at Ku band and 238 packaged MMIC at C-band.

- **LTCC and HTCC - The System in Package (SiP) Platform:** First space qualified indigenous LTCC foundry on Ferro-A6ME tape system, with 100GHz circuit capability having 100µm via & line width/spacing along with assembly process is established. Following circuits were developed: (a) LTCC Qualification samples development and Space Qualification using FERRO A6ME tape system, (b) LTCC board for BFU circuits, (c) C-band TRM, (d) Transitions: DC to 40 GHz CPW to micro strip transition & V band waveguide to micro strip transition, (e) Single layer LTCC process for accelerometer, (f) Ka-band LNA package with low-loss waveguide to micro strip transition, (g) IC package using HTCC.

- **Micro optical components development:**

  - Developed, tested and fabricated Electron Beam Lithography for 125 gr/mm grating having Blaze Angle of 2.15° - Process developed, gratings fabricated and tested.
  - Electron Beam Lithography for 45 gr/mm grating having Blaze Angle of 2.2° - Process developed, gratings fabricated and tested.

- **Electronic fabrication - MLB, Rigid-flex, CCGA**

  Following new processes developed & qualified for space use:

  - Conformal Coating & Silver Epoxy Removal process using Sand-Blasting
  - Nano-D Connector Assembly & Soldering for Carto-2C
  - Vertex-4 CCGA Assembly & soldering with LASER reflow system qualified
  - Heat Sink Assembly process on Vertex-4 CCGA device for Scatsat-1
  - MMIC Lid Sealing with Hot Gas (N2) reflow system

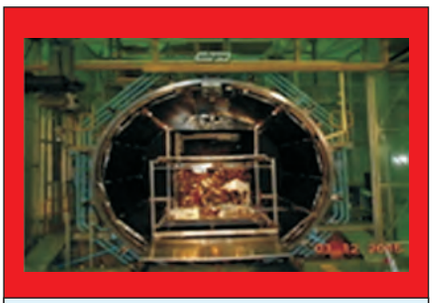
- **Plating and Surface treatment:**

  Following processes are developed and qualified:
  - White thermal paint removal from antenna reflector
  - Electroless Silver plating on multiplanar waveguides (Length 1200 mm)
  - Gold plating on Ka-band Aluminum waveguide coupler
  - 50µ Silver plating on Aluminum Alloy 6061T6 detector caps - For Chandrayan-2, XSM P/L
  - Silver plating on copper foils without undercoat - For Chandrayan-II, SCATSAT-1
  - Developed and qualified 6 new processes on magnesium Mg AZ31B.

- **Thermo-Vacuum and Climatic tests**

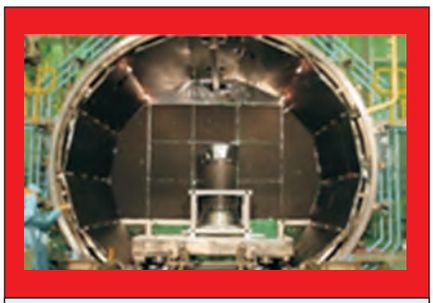
  - Operation & Maintenance of 55 chambers (including 24 chambers installed at various users laboratories)
  - Cooling system of 2 Hot/Cold chamber augmentation (C-4606-A-03 & Walk in Chamber) Completed

- Control system of one Hot/Cold chamber augmentation with Integrated PLC+HMI unit. Completed.



GSAT-18(5.5m)

IRNSS 1E & 1F



CARTO-2C

Few major Thermovac test on satellite payload level.

- **Electronic support**
  - Bio-Metric ACS System implementation:Hardware installation is completed & software is in final stage of implementation.
  - CCTV Surveillance System Installed:
    - Installed IP-Cameras at DES (14) & ISRO Colonies (3)
    - CCTV expanded to 53 IP-cameras
    - Video Management Software (VMS) upgraded to Open Network Video Interface Forum(ONVIF)
  - Augmentation of Power fencing at SAC:
    - Augmented power fencing with Optical Fiber cable (OFC) to solve connectivity problem with control room.
    - Established optical-fiber connectivity between New-Auditorium and Vikram hall for live projection of event at either location

- **Calibration and repair:**
  - Desktop Surveillance by NABL was successfully completed.
  - Established calibration / validation facility up to 220GHz
  - Procuring Vector Signal Generator in Ka-band for Digital Modulation Generation.
  - Developed in-house (ATP) Automated Test Programs for 33 new models for incoming inspection / calibration / repair of T&ME.
  - Commissioning of T&ME:
    - Reference Frequency Standard Hydrogen Maser VCH 1008
    - Source Module (220 GHz) and Programmable Attenuator (140-220 GHz).
  - Repairs of Fabrication & Process Equipment – 160 repairs completed.

- **Networking and IT Infrastructure:**

  During this year following works are completed and operationalized.
  - Active Directory Service enabled for Single Sign on user authentication based services
  - Thin Client Infrastructure installation & commissioning for secured Internet
  - Commercial email solution infrastructure commissioned
  - Renewed Organization wide AntiVirus solution, BSNL and Railtel leased line for internet
  - Ad-hoc Wi-Fi installed and initiated for further extension
  - Network at perimeter, buildings and labs entries for Access Control System (ACS)
  - Multi-level (7 locations) and Multi-Layer perimeter security implementation

- Operation and Maintenance for 24X7 services
- Server Cloud, Desktop Cloud and Workstation Cloud RFP is finalized.

Antenna Test Facilities:

Following antenna test facilities are utilized regularly for carring out antenna measurement activities:

- Compact Antenna Test Facility (CATF)
- Planar Near-Field Facility (PNF)
- Anechoic Chamber

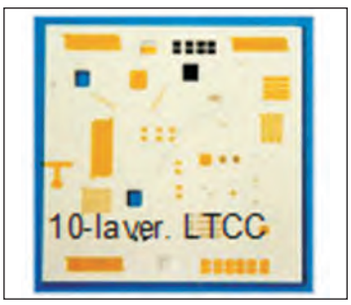
Reliability and Quality Assurance

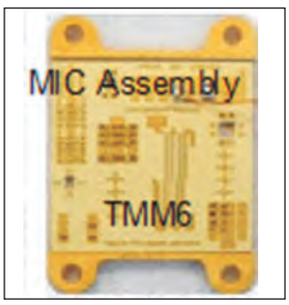
Quality assurance activities were carried out for on-going and future projects consisting of nine communications, three navigation, eight optical remote sensing and seven microwave remote sensing payloads. (GSAT-9,11,15,17 through 20, IRNSS-1E,1F,1G, GISAT, Cartosat-2C, INSAT-3DR/3DS, Chandrayaan-2 (optical & SAR P/Ls), Aditya, microsat, RISAT-1A,2A, Resourcesat-2A, Scatsat-1, NISAR, Oceantsat-3 etc). Bonded Stores provides central repository of EEE components, materials, bare PCBs, fabricated hardware and subsystems in a controlled environment of class 100,000 with proper humidity, temperature maintained 24X7 for 365 days, including test reports and documents received from manufacturer for all bought out parts, materials and subsystems.

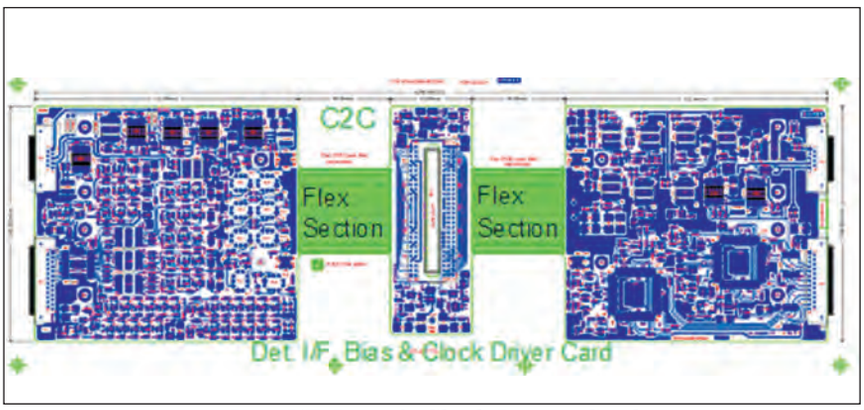
Quality Assurance activities related EEE parts, Optics and Optoelectronics components, all classes of E-O Detectors, Cryo-coolers & Atomic clocks, Schematics and package drawing review, batch acceptance of PCB, MIC, plated & painted parts, T&E are carried out. 21 new electronic, 3 mechanical and 6 surface treatment processes are qualified.

Activities related to training, certification & subsystem audits for sub-contractors BEL-Bangalore, BEL-Ghaziabad, Komoline-Ahmedabad, AMPL- Hyderabad & Centum – Bangalore are carried out. Major activities are as follows:

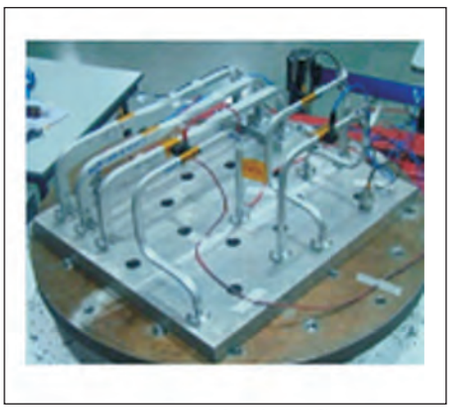
- 10-layer Flexi-rigid MLB with 2mil/6mil flex layer fabricated by indigenous vendor qualified for first time in ISRO and successfully met C2C FPA realisation
- Vendor developed for 14-layer rigid MLB qualified for the first time in ISRO to meet emerging highly complex remote sensing payloads
- MIC assembly processes on soft RF substrates (in-house as well as sub-contractors) and LTCC substrates (in-house) to meet on-going GEOSAT payloads and L-band as well as X-band SAR TR module requirements were qualified
- In-house processes of Bending and TIG welding for WR-75, WR-51 and WR-28 wave guide assemblies were qualified







Det. I/F, Bias & Clock Driver Card



WR75,28,51 W/G

- Process of making parts using Direct Metal Laser Sintered (DMLS) Invar was qualified for space use
- Qualification of Internal cold thread forming on Al Alloy AL6061 T6 for M2x0.4 threads is carried out successfully
- More than 2,31,590 components were inspected and cleared for QM/FM subsystems. Screening and Lot Acceptance testing of in-house fabricated SAW filters for DRT Rx (INSAT-3DR) realized for the first time
- Life test of more than 5,000 device-hrs was carried out on MMIC as part of experiment to evaluate environmental effect on Bare chip in absence of hermetic sealing
- Reliability estimation of GSAT-17/11/7A, Carto-2C and Scatsat-1 payloads was done. Functional FMECA was carried out for GSAT-17 & GSAT-11 communication payloads. Piece-part FMECA and Electrical Stress Analysis of 115 circuits and Failure Rate prediction of total 49 subsystems of communications and remote sensing payloads was carried out
- ESD test setup for Radiated field ESD test, Single point discharge ESD test & Structural current ESD test is procured and commissioned

Research & Development
Activities

RESPOND

In house as well as sponsored and collaborative research activities are carried out at SAC. At present 47 sponsored research projects are going on under RESPOND.

The 16th Annual Review of RESPOND (ARR) Projects was organized at SAC during November, 2015. The participants included Respond Review Committee (RRC) members, Principal Investigators (PIs), SAC Focal Persons (SFPs), Subject experts, SAC Management Council (SMC) and SAC Council Board (SCB) Members, and other invitees. Apart from SAC Participants, there were 50 participants from various academic & other institutions. Thirty Ongoing Projects were reviewed during this ARR.

Second compendium covering 151 papers of research carried out during January 2013 to December 2014 under TDP/R&D programme, projects, Respond programme and Space Technology Cells is published. The document is divided in two volumes under eight themes namely (i) Satellite Communication, (ii) Satellite Navigation and applications, (iii) Antennas, (iv) Electro Optical Sensors, (v) Microwave Sensors, (vi) Image processing and Applications, (vii) System Reliability, (viii) Processes development.

The ongoing research projects of RESPOND are reviewed in Annual RESPOND Review at SAC and also six projects are reviewed in each meeting of RESPOND Review Committee. Most of RESPOND projects are of the duration of 2-3 years.

TDP & R&D

At present 94 TDP/R&D activities are going on at the centre. A document of Evaluated and Completed TDP/R&D Activities during July 2014 – December 2014 is released in July 2015. Evaluation of 35 TDP/R&D Activities Completed in May 2015 covered in the document. The Document covers Concept, Outcome, Evaluation of Completed TDP/R&D activities and financial support.

The overall outcome from 35 completed TDP/R&D activities under various parameters is as follows.

a. Total Human Resources Developed:
- Focal Points and Team members : 112

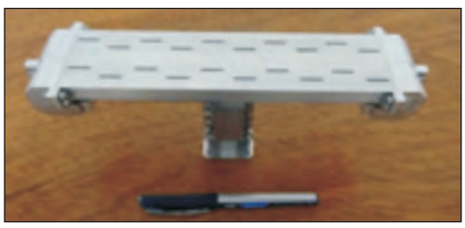
b. Total Papers/Reports Published/IPR:
- Papers Published : 26
- Reports/ User Manual generated : 45
- IPR (Patent/ Copyright) : 2
- Total: 73

c. Technological development:

- Methodology / Techniques delivered : 13
- Algorithms/ Software/ Model developed : 20
- Hardware developed : 23

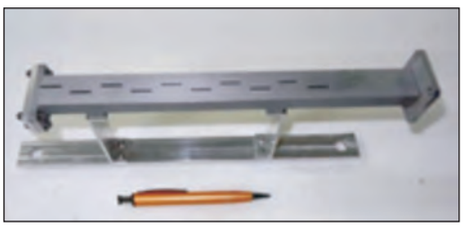
Some of the important TDI & R&D programme are:

2 x 10 planar broadband slotted waveguide array antenna: The design, development and characterization of 2 x 10 planar array antenna incorporating virtual short technique is completed. This bandwidth enhancement technique is further being used to design 8 x 8 planar array antenna at X band. The successful development of this technology will be gainfully utilized in the space-borne X-band SAR for higher antenna efficiency and better reliability.



2 x 10 planar broadband slotted waveguide array antenna

1 x 10 linear post tuned slotted waveguide array antenna: The bandwidth enhancement techniques such as subarray feeding using coupling slots and post matching technique have also been explored. The design, development and characterization of 1 x 10 linear array antenna with coupling slot feeding is completed. The design, development and characterization of 1 x 10 linear post tuned slotted waveguide array antenna is also carried out and its measured return loss performance showed 4.8 % bandwidth.



1 x 10 linear post tuned slotted waveguide array antenna

Four Channel Waveguide Rotary Joint at C/Ku bands: Designed and developed four channel waveguide rotary joint at C/Ku bands The rotary joint shows ~100 MHz return loss, insertion loss bandwidth at both C band (5.35 GHz) and Ku band (13.515 GHz) channels. RF simulations for power handling analysis performed at critical places like gaps at slots, RF chokes for 100 watts at Ku band and 150 watts at C band shows worst case margin better than 25 dB. These devices are useful for earth station scanning antenna systems.

Waveguide Rotary Joint

Design and Analysis of Double Curvature Shaped Reflector Antenna: Cosecant squared pattern reflector antennas are frequently used in air-surveillance radar systems, where the radiation pattern of the antenna compensates for the free-space loss. The radiation characteristics of the tracking antenna system at the ground control station play a significant role for accurate tracking of an airborne target. Synthesis of reflector surface for cosecant squared pattern is carried out based on Energy conservation and Geometrical Optics by applying numerical techniques. Synthesized surface has been optimized using Genetic and Minmax algorithm to reduce ripples in the shaped region and to improve the side lobe level in orthogonal plane. Development of antenna is completed and characterized at SAC CATF.

Antenna in SAC CATF

High Efficiency Single Aperture Single Feed per Beam Multibeam Antenna: Realized high efficiency single feed cluster and success fully tested with GSAT-3 offset reflector. Measured Beam to beam isolation is 17.5 dB for North –to –south beam and 20 dB for East to West beam. EOC gain improved compared to a conventional single aperture Multibeam antenna.

Dual Layer Fabry Perot Cavity Antenna Feed

Management Support
Activities

Budget & Project progress Monitoring

Throughout the year a large number of projects and research activities are going on within the Centre. In order to evolve an effective project monitoring mechanism in the Centre, a compilation of the scheduled activities and subtasks of all the projects and TDP activities of the Centre are carried out. Centre has a project & progress Monitoring Division (PPMD) for monitoring the progress of the project through systematic & periodical reviews and also provide support by planning/preparing proposals for new projects. The progress of various projects is monitored by different committees regularly. Monthly progress report of the Centre is compiled every month and highlights of the activities are generated. A detailed compilation of the Centre's activities was carried out and the Annual report of the Centre for the year 2014-2015 was generated.

The annual budget exercise for Revised Estimates & Budget Estimates commences from the issue of budget circular by Director, SAC calling for budget proposals from entities/projects. It is necessary to plan for the utilization of funds well in time taking into account the programmatic schedules and also the plan for major procurements in the beginning of the financial year itself, so that there is no uncertainty about the delivery as well as payment of schedules at the end of the financial year. Project & Progress Monitoring Division of the Centre provide support in monitoring the expenditure of budget throughout the year to achieve the financial targets. Centre budget expenditure crossed Rs. 500 crores for the first time in the financial year 2015-16. Budget expenditure has depicted smooth and well planned operation where spending is 23.51% in first quarter, 20.26% in second quarter, 22.68% in third quarter and 33.48% in fourth quarter.

Human Resources Development

11 in-house programmes were designed and organized with 230 participants. This includes ISRO Level programme IITP-27 and two Structured Training Programmes (STP). Besides, 15 other programmes were organized including Seminars/Educational visits.

256 staff members deputed to attend various conferences/seminars/training courses etc. About 66 papers were presented by Scientists/Engineers in various Conferences/Symposiums/et al. 38 higher-studies cases were also recommended.

19 lectures under SAC Lecture Series and 6 lectures under Knowledge Sharing Series are organized. 2 events were also conducted under Know Your Achievements platform on GSAT 16 & GSAT 6.

197 students from various academic institutions located in different parts of the country benefited during 2015-16 under SAC-Academic Associate Program me.

Technology Transfer and Patents

SAC has signed the following 28 MoUs with different agencies:

- Academic Research Collaboration with Indus University, Ahmedabad, DA-IICT, Gandhinagar and Nirma University (NU)
- GSAT-6/High Power MSS terminals miniaturisation, packaging and production based on SAC design with M/s Astra Microwave Products Ltd, M/s Avental Ltd, M/s Centum Electronics Ltd,

M/s Data Patterns (India) Pvt. Ltd., M/s Komoline Aerospace Ltd and M/s Wavelet Technologies

- IRNSS Navigation Receiver Field Trial and Data Collection with Airports Authority of India, Bhagwan Mahavir College of Enigneering and Technology, The University of Burdwan, Indian Institute of Technology, School of Engineering & Technology, Jain University, K L University, Smt. Kasturbai Walchand College, Mizoram Remote Sensing Applications Centre, MVJ College of Engineering, M/s Saankhya Labs Pvt. Ltd., Indian Institute of Technology , Skivaji University, Vidyanagar and Institute of Seismological Research (ISR)
- Providing Technical Assistance to ECIL for Development of Multi-Band Composite Feed Systems for Earth Stations with M/s Electronics Corporation of Inida Ltd (ECIL)
- The scientific cooperation in System of Air quality and weather Forecasting and Research for Ahmedabad (SAFAR – Ahmedabad) with Indian Institute of Tropical Meteorology (IITM)
- Establishment of technical co-operation for the development of satellite payload hardware using composite / advance materials with Ahmedabad Textile Industry's Research Association
- GSAT-6/ High Power MSS terminals miniaturisation, packaging and production based on SAC design with The Tata Power Company Limited

TT Agreements

- SAC has signed 3 technology transfer agreements for15W C Band Solid State Power Amplifier, Gold Plating on Aluminium 6061 T6 and Kovar and Cr-Cu-Au Metallization process on Alumina substrates with M/s Centum Electronics Ltd, M/s Komoline Aerospace Limited and M/s Carborundum Universal Ltd respectively.
- Technical Consultancy on Development of Radar level Transmitter was provided to SAPCON Instruments Pvt., Indore

Testing facility support provided by SAC to Industry partners

Sr. No.	Name of Test to carried out	Name of Company
1	EME/EMC test	Centum Electronics Ltd.
2	Re-certificate Exam without imparting Traning For PCB Wiring & Assembly	Komoline Aerospace Ltd.
3	EMI/EMC Facility	Astra Micriwave products Ltd
4	RS 103 EMI/EMC Test	BEL, Gaziabad
5	Outgassing tests TML and CVCML	Centum Electronics Ltd.
6	RS 103 EMI/EMC Test	BEL, Gaziabad
7	Mechanical Shock testing 5w SSPA	Astra Micriwave products Ltd
8	EMI/EMC test on 2 FM (C-Band MMIC Receiver	BEL, Gaziabad

Patents Granted

Sr No.	Title of Patents	Patent Grant No.	Patent Date
1	A Novel method of In Situ Near Field Antenna Pattern Measurement	272096	17/03/2016
2	Sector Shaped Beam Antenna Using Dual Parabolic Configuration	266322	27/04/2015
3	A New Method of Collimation of Active Array Antenna by Simplified Near Field scan	266750	29/05/2015
4	A UHF Miniature Meandered Microstrip patch anenna for mobile communicaitons and Method of Production Thereof	266801	03/06/2015
5	An Improved Method for Obtaining flat Pass Band response in a Surface Acoustic wave (SAW) Filter	267108	26/06/2015

Patents Filed

Sr No.	Title of Patents	Application No.	Application Date
1	Gallium Nitride Based S-Band Solid State Power Amplifier	3493/CHE/2015	08/07/2015
2	Adaptable and Flexible Temperature Compensation mechanism for Microwave Resonator Cavity	3386/CHE/2015	02/07/2015

Manpower & Information System:

Manpower and Information System at the centre mainly focuses on implementation and operations of Office Automation System, Technical support to Personnel & General Administration, Purchase & Stores and Finance & Accounts for data processing, networking & developing software for their day to day functions

During the year first Android based App अंश is developed for providing complete CHSS doctors information with integrated google map and direct calling facility to users. Additionally, it also gives information about ISRO guest houses, CHSS supplementary item norms and centre holidays. The App is given to ISAC Banglore in order to share with Bengaluru based units.
In order to provide a platform for the retiring SAC employees to showcase commendable work done during service, online system – अनुभव @ SAC is launched and inaugurated by Chairman, ISRO. This is also shared with all ISRO centres.

Capacity Building

During the year following training programmes are conducted:

- Tenth Post Graduate Diploma Course in Satellite Communications – SATCOM-10 with 16 participants

- Short term training programme on Global Navigation Satellite System - GNSS-1 with 9 participants
- MIC Inspector and Fabricator certification Training was conducted for Komoline Aerospace Ltd. in two batches

Vikram Sarabhai Space Exhibition (VSSE)

Renovated VSSE was inaugurated by Shri Kiran Kumar, Chairman ISRO in presence of Shri Tapan Misra, Director SAC, Shri Vikram Desai, Director DECU and Veterans like Shri Pramod Kale and Shri Kiran Karnik on August 21, 2015. The exhibition was declared open to the general public on October 4, 2015. Major attraction of this exhibition is: (i) virtual presenter (ii) augmented reality (iii) GSLV animation (iv) 3D TV without spectacles (v) 3D auditorium (vi) interactive Bhuvan (vii) Flight suit for Space exploration (viii) kids section (ix) quiz section (x) Holography type Display.

VSSE has a 3D theatre accommodating 70 visitors. Relevant movies like IRNSS-1F, IRNSS-1G, the Mars Orbiter Mission are being screened. To give a feel of the 3D to the audience international films like International space Station, Space Shuttle and other demo films are also screened. So far about Seventy-five thousand people have enjoyed the film show.

Documentaries on IRNSS-1F, IRNSS-1G and the Mars Orbiter Mission are screened regularly in VSSE's 3D theatre and about seventy-five thousand visitors have enjoyed these shows during the year.
In order to extend the outreach to rural and urban population VSSE arranges mobile exhibitions consisting models, static panels and documentaries. During the year mobile exhibition are arranged at following places:

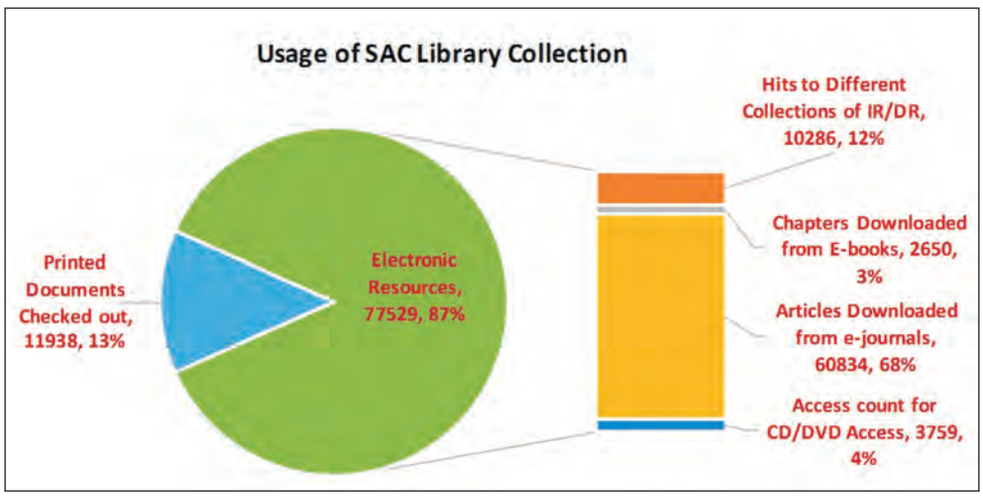
- Ankleshwar, Surat (2 times), Godhra, Palanpur, Panthwada, Bhavnagar in Gujarat
- Pune, Chinchwad and Kalyan in Maharashtra
- Indore, Mandsaur in M.P.
- Bulandshahr in U.P.; and Roorkee in Uttarakhand.

The estimated number of visitors at these mobile exhibitions varies from 15000 to 50000.

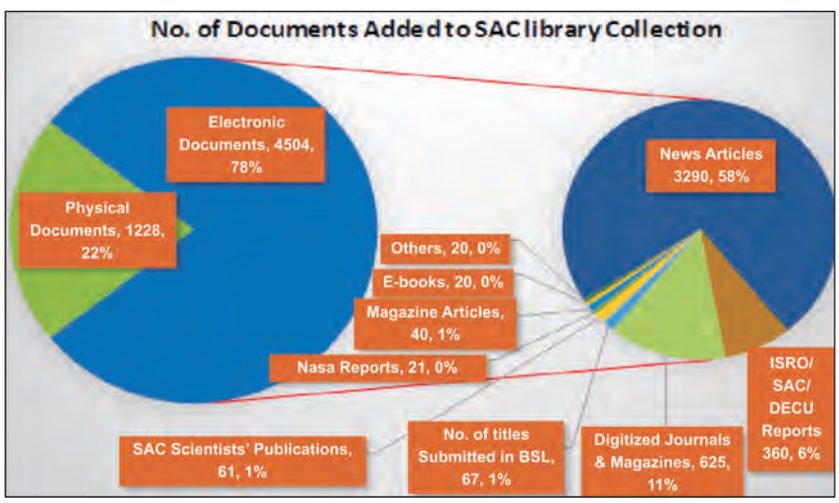
Library

Persisting on its dual objective of fulfilling information needs of researchers and preserving institutional research output for posterity, SAC Library continued its focus on acquiring and providing access to the digital resources, along with maintaining its hybrid nature by procuring printed documents, wherever required.

During 2015-16, total physical footfalls to library were approx. 65,000, whereas hits to different pages of Library website, acting as host to deliver different electronic resources such as- mirrored CD/DVDs, NPTEL Videos, Institutional and Digital Repositories, News Clips etc.; were accounted to be 3,93,387. Over all usage of acquired information resources is depicted in graph below.


Usage of SAC Library Collection
Hits to Different Collections of IR/DR, 10286, 12%
Chapters Downloaded from E-books, 2650, 3%
Articles Downloaded from e-journals, 60834, 68%
Access count for CD/DVD Access, 3759, 4%
Printed Documents Checked out, 11938, 13%
Electronic Resources, 77529, 87%

Users' preference of remote and electronic access to information, was duly kept in mind while procuring information resources, and approximately 78% of total documents added during the year were in electronic format including 250 DVDs containing NPTEL videos courses of approximately 50,000 hours. 120 printed periodicals and 575 e-journals were renewed / subscribed from major publishers such as IEEE/IET, Springer, Science Direct, John Wiley, Taylor & Francis, SPIE, AMS, AIP, OSA etc, facilitating full text access using Internet from SAC, Bopal as well as DES Campuses. SAC library renewed institutional memberships of ION, IPC and acquired Lifetime Institutional Membership of Current Science Association (CSA).


No. of Documents Added to SAC library Collection
Electronic Documents, 4504, 78%
Physical Documents, 1228, 22%
News Articles 3290, 58%
Others, 20, 0%
E-books, 20, 0%
Magazine Articles, 40, 1%
Nasa Reports, 21, 0%
ISRO/ SAC/ DECU Reports 360, 6%
SAC Scientists' Publications, 61, 1%
No. of titles Submitted in BSL, 67, 1%
Digitized Journals & Magazines, 625, 11%

This year library extended its memberships to 387 regular and retired employees, student trainees, apprentices, JRFs etc. Total 178 requests for journal articles on Inter Library Loan (ILL) from our users and other libraries were received out of which 117 were fulfilled. 58 books and monographs were also exchanged on ILL with various cooperating libraries. In reprographic facility of SAC Library, approx. 3,03,705 B&W and 228607 color pages were printed, and 3,452 documents were bounded in-house.

As its major initiatives during the year SAC Library premises was made WiFi enabled for smoother access to e-resources; Holding data of books available at SAC library was hosted at IndCat (INFLIBNET) for web-scale discovery and resource sharing; User awareness program for IEEE resources and EBSCO Discovery Service were organized; A "Language Laboratory" for learning Hindi from other regional languages was established; Book Exhibitions of Hindi books on the occasion of Hindi Mah and S&T books received from vendors 'on approval basis' were organized. Also, library signed an agreement with CrossRef and procured Digital Object Identifier (DOI) for data sets and other digital objects.

हिंदी गतिविधियां

05 अगस्त 2015 को " समाज, विज्ञान एवं सुरक्षा के लिए अंतरिक्ष " विषय पर हिन्दी तकनीकी संगोष्ठी का आयोजन किया गया, इसके साथ ही "अंतरिक्ष प्रौद्योगिकी के क्षेत्र में राजभाषा के प्रगामी प्रयोग" विषय पर राजभाषा सत्र भी शामिल किया गया। संगोष्ठी में अंतरिक्ष उपयोग केंद्र (सैक) तथा विकास एवं शैक्षिक संचार यूनिट (डेकू) के वैज्ञानिकों तथा अन्य स्टाफ सदस्यों ने सहभागिता की। संगोष्ठी के लेख-संग्रह का विमोचन किया गया, लेख संग्रह संगोष्ठी के लेखक प्रतिभागियों द्वारा प्रस्तुत लेखों का संकलन है। संगोष्ठी के लेख-संग्रह को सीडी के रूप में भी तैयार किया गया था। संगोष्ठी का आयोजन कुल चार सत्रों में किया गया, जिनमें से तीन सत्रों में तकनीकी लेख प्रस्तुत किए गए और प्रथम सत्र में राजभाषा हिंदी से संबंधित लेख प्रस्तुत किए गए। प्रत्येक सत्र की सर्वश्रेष्ठ प्रस्तुतियों तथा संगोष्ठी के अन्य प्रतिभागियों को प्रमाण-पत्र प्रदान किए।

सैक तथा डेकू में विगत कई वर्षों से हिन्दी माह का आयोजन किया जाता है जिसमें कार्यालय के कर्मचारी अत्यंत उत्साह से प्रतिभागिता देते हैं। वर्ष 2015 में भी सितंबर माह के दौरान हिंदी माह का आयोजन किया गया। हिन्दी माह के दौरान हिंदी भाषी वर्ग के लिए 12 तथा हिंदीतर भाषी वर्ग के लिए 12 हिंदी प्रतियोगिताओं का आयोजन किया गया। इनमें से 2 प्रतियोगिताएं हिन्दी प्रश्नमंच एवं हिन्दी काव्यपाठ में स्टाफ सदस्य तथा दर्शक गण उल्लास के साथ भारी संख्या में भाग लेते हैं। हिन्दी प्रश्नमंच प्रतियोगिता दो भागों में पहले ऑनलाइन (स्टाफ सदस्य अपने डेस्कटॉप पीसी से भाग ले सकते हैं) तत्पश्चात् मौखिक रूप से आयोजित की जाती है, जिसमें प्रतिभागी तथा स्टाफ सदस्य काफी उत्साह का प्रदर्शन करते हैं। इस वर्ष हिंदी प्रतियोगिताओं के प्रतिभागियों की संख्या 1200 रही। हिन्दी माह के दौरान कर्मचारियों के बच्चों तथा विवाहितियों के लिए भी विविध प्रतियोगिताएं आयोजित की जाती हैं, जिसमें विवाहितियों के लिए आयोजित हिन्दी अंताक्षरी प्रतियोगिता काफी रोचक व लोकप्रिय है। हिंदी माह के दौरान 01 सितंबर से 30 सितंबर 2015 तक सैक पुस्तकालय में वर्ष के दौरान खरीदी गई हिंदी पुस्तकों की एक प्रदर्शनी भी आयोजित की गई।

निदेशक, सैक की अध्यक्षता में सैक की राजभाषा कार्यान्वयन समिति की 26/06/2015 को 141वीं, 30/09/2015 को 142वीं, 14/12/2015 को 143वीं तथा 31/03/2016 को 144वीं बैठक का आयोजन किया गया। जिसमें संबंधित तिमाहियों के दौरान केंद्र में राजभाषा नीति के अनुपालन की समीक्षा की गई। राजभाषा कार्यान्यन से संबंधित महत्वपूर्ण चर्चा की गई तथा केंद्र में प्रभावी राजभाषा कार्यान्वयन के लिए महत्वपूर्ण निर्णय लिए गए। समिति में चर्चा के उपरांत राजभाषा विभाग द्वारा जारी वार्षिक कार्यक्रम 2015-2016 की प्रति सभी संबंधितों को परिचालित की गई।

वर्ष के दौरान 04 राजभाषा कार्यशालाओं का आयोजन किया गया जिनमें 12/05/2015 को वैज्ञानिक/अभियंता एससी वर्ग के 57 अधिकारियों, 24/07/2015 को वैज्ञानिक/अभियंता एससी वर्ग के 58 अधिकारियों, 29/12/2015 को वरिष्ठ परियोजना सहायक, वरिष्ठ सहायक, सहायक वर्ग के 100 कर्मचारियों के लिए विशेष कोवा केंद्रित राजभाषा कार्यशाला और 08/03/2016 को वैयक्तिक सचिव/परि.वैयक्तिक सचिव, वरिष्ठ वैयक्तिक सचिव वर्ग के 24 कर्मचारियों को संघ की राजभाषा नीति, नियम, कार्यान्वयन तथा कंप्यूटर पर हिंदी में काम करने संबंधी विशेष प्रशिक्षण प्रदान किया गया।

सैक द्वारा तैयार मंगल कक्षित्र मिशन एटलस का हिंदी संस्करण तैयार किया गया जिसका विमोचन माननीय राज्य मंत्री, प्रधानमंत्री कार्यालय श्री जितेंद्र सिंह ने 26 अक्तूबर 2015 को संयुक्त राजभाषा सलाहकार समिति की बैठक के दौरान किया।

अप्रैल 2015 के दौरान हिंदी गृह पत्रिका अभिव्यक्ति के 9वें अंक का विमोचन निदेशक, सैक द्वारा किया गया। पत्रिका अंतरिक्ष विभाग/ इसरो के विभिन्न केंद्र/यूनिटों को प्रेषित की गई। अभिव्यक्ति के 10वें अंक के लिए परिपत्र जारी कर सैक/डेकू स्टाफ सदस्यों से रचनाएं आमंत्रित की गई।

इसरो में कम्प्यूटर कार्यप्रवाह प्रणाली (कोवा) के माध्यम से जारी किए जाने वाले विविध आदेशों को द्विभाषी में जारी किए जाने के लिए सैक द्वारा कोवा हिन्दी प्रणाली का विकास किया गया। इसरो के विविध केंद्रों/यूनिटों द्वारा इस प्रणाली का उपयोग द्विभाषी आदेश जारी किए जाने के लिए किया जा रहा है। अंतरिक्ष विभाग की पहल पर कोइन्स प्रणाली के अंतर्गत सैक द्वारा विभिन्न प्रशासनिक, लेखा, क्रय तथा भंडार संबंधी प्रारूप द्विभाषी रूप में तैयार किए।

सैक के एमआईएसडी प्रभाग के सौजन्य से हिन्दी प्रशिक्षण रोस्टर प्रणाली के माध्यम से कोवा से इनपुट प्राप्त कर कर्मचारियों के हिन्दी ज्ञान तथा हिन्दी प्रशिक्षण का अद्यतन रोस्टर तैयार किया जाता है।

हिंदी शिक्षण योजना के अंतर्गत सैक में नवनियुक्त 08 प्रशासनिक सहायकों के लिए फरवरी-जुलाई 2015 सत्र के लिए कंप्यूटर पर हिंदी टंकण प्रशिक्षण संचालित किया गया। जुलाई 2015 के तीसरे सप्ताह में हिंदी शिक्षण योजना द्वारा आयोजित हिंदी टंकण परीक्षा में इस केंद्र के उक्त 08 सहायकों ने हिंदी टंकण की परीक्षा में भाग लिया। हिंदी टंकण प्रशिक्षण हेतु शेष 07 कर्मचारियों को हिंदी शिक्षण योजना के अंतर्गत फरवरी-जुलाई 2015 सत्र के लिए प्रपत्र भरवाकर नामित किया गया।

वर्ष के दौरान अधिकतर कार्यालयीन काम हिंदी में करने हेतु लागू प्रोत्साहन योजना के अंतर्गत हिंदीतर भाषा वर्ग एवं हिंदी भाषा वर्ग के 22 स्टाफ सदस्यों को पुरस्कार प्रदान किया गया। इसके अलावा तकनीकी अनुभागों में हिन्दी कार्यान्वयन को बढ़ावा देने के उद्देश्य से वर्ष के दौरान प्रोत्साहन योजना लागू की गई।

अंतरिक्ष उपयोग केंद्र तथा विकास एवं शैक्षिक संचार यूनिट (डेकू), अहमदाबाद में जनवरी 2016 माह में विश्व हिंदी दिवस मनाया गया। इस अवसर पर 09 जनवरी 2016 को सैक तथा डेकू के कर्मचारियों के लिए हिंदी निबंध एवं हिंदी वार्तालाप प्रतियोगिता का आयोजन किया गया। प्रतियोगिताओं में कर्मचारियों ने उत्साहपूर्वक भाग लिया और उन्होंने कार्यालयीन एवं निजी जीवन में राजभाषा हिंदी का अधिक से अधिक प्रयोग करने तथा अन्य लोगों को भी हिंदी अपनाने के लिए प्रेरित करने का संकल्प दोहराया।

केंद्र में सतर्कता सप्ताह के दौरान हिंदी निबंध, हिंदी आशुभाषण एवं हिंदी प्रश्नमंच इस प्रकार 03 हिंदी प्रतियोगिताओं का आयोजन किया गया और इसी भाँति सुरक्षा सप्ताह के दौरान भी हिदी निबंध, हिंदी आशुभाषण तथा हिंदी नारा लेखन इस प्रकार 03 हिंदी प्रतियोगिताओं का आयोजन किया गया।

केंद्र के सभी प्रकार्यात्मक पदनामिक अधिकारियों को कार्यालय में प्रयोग करने हेतु वैज्ञानिक तथा तकनीकी शब्दावली आयोग द्वारा प्रकाशित प्रशासनिक शब्दावली (हिंदी-अंग्रेजी तथा अंग्रेजी-हिंदी) का वितरण किया गया।

राजभाषा विभाग द्वारा जारी लक्ष्यों के अनुसार पुस्तकालय में हिन्दी पुस्तकों की खरीद की गई। जिसका विवरण निम्नानुसार हैः

सामान्य पुस्तकों पर किया गया कुल खर्च	अंग्रेजी पुस्तकों पर किया गया कुल खर्च	हिंदी पुस्तकों/ पत्रिकाओं पर किया गया खर्च	हिंदी पुस्तकों पर किये गए खर्च का प्रतिशत	कुल हिंदी पुस्तकों की संख्या
रु. 58371.00 (संदर्भ ग्रंथों को छोड़कर)	रु.11927.00 (सामान्य पुस्तकों पर, संदर्भ ग्रंथों को छोड़कर	रु. 46444.00	79.50%	174

प्रशासनिक क्षेत्र के कर्मचारियों को उनके अनुभाग में जाकर हिन्दी अनुभाग के कार्मिकों द्वारा कंप्यूटर पर हिन्दी में कार्य करने का प्रशिक्षण प्रदान किया गया।

अंतरिक्ष विभाग द्वारा जारी विक्रम साराभाई मौलिक हिन्दी पुस्तक लेखन योजना का सभी स्टाफ सदस्यों के बीच व्यापक परिचालन किया गया।

केंद्र के सेवानिवृत होने वाले कार्मिकों के लिए प्रत्येक माह आयोजित होने वाले विदाई समारोह संबंधी सभी कार्य हिंदी में किए गए।

केंद्र की मासिक प्रगति रिपोर्ट का हर माह नियमित रूप से हिंदी रूपांतरण तैयार कर विभाग को प्रेषित किया गया।

निदेशक, सैक ने 26 जनवरी 2016 को अंतरिक्ष उपयोग केंद्र परिसर में गणतंत्र दिवस समारोह के दौरान सैक/ डेकू में हिंदी कार्यान्वन से संबंधित विभिन्न गतिविधियों/ प्रोत्साहन योजनाओं के विजेता प्रतिभागियों तथा 10वीं तथा 12वीं कक्षा में हिंदी विषय में सर्वाधिक अंक प्राप्त करने वाले सैक/डेकू स्टाफ सदस्यों के बच्चों को पुरस्कृत किया।

पुरस्कार

अंतरिक्ष उपयोग केंद्र (सैक) को अहमदाबाद नगर में केंद्रीय कार्यालयों (100 से अधिक कर्मचारी संख्या) की श्रेणी में वर्ष 2014-15 के दौरान सर्वश्रेष्ठ राजभाषा कार्यान्वयन हेतु नगर राजभाषा कार्यान्वयन समिति, अहमदाबाद की ओर से 21 जुलाई 2015 को भारतीय प्रबंधन संस्थान, अहमदाबाद के प्रेक्षागृह में संपन्न अहमदाबाद नराकास की 66वीं बैठक के दौरान द्वितीय पुरस्करार से सम्मानित किया गया। विकास एंव शैक्षिक संचार यूनिट (डेकू) को अहमदाबाद नगर में स्थित केंद्रीय कार्यालयों (100 से कम कर्मचारी संख्या) की श्रेणी में वर्ष 2014-15 के दौरान सर्वश्रेष्ठ राजभाषा कार्यान्वयन हेतु नगर राजभाषा कार्यान्वयन समिति, अहमदाबाद की ओर से 21 जुलाई 2015 को भारतीय प्रबंधन संस्थान, अहमदाबाद के प्रेक्षागृह में संपन्न अहमदाबाद नराकास की 66वीं बैठक के दौरान प्रथम पुरस्करार से सम्मानित किया गया।

नराकास के तत्त्वावधान में संपन्न हिंदी निबंध प्रतियोगिता में श्री मुकेश मिश्र, पुस्तकालय अधिकारी-सी, सैक को द्वितीय स्थान प्राप्त करने के उपलक्ष्य में 21 जुलाई 2015 को 66वीं नराकास बैठक में पुरस्कार प्रदान किया गया। श्री जी.चंद्रशेखर प्रधान, कार्यालय एवं सामान्य प्रशासन को राजभाषा नीति नियमों पर ऑनलाइन प्रतियोगिता में द्वितीय स्थान प्राप्त करने के उपलक्ष्य में 28 जनवरी 2016 को संपन्न 67वीं बैठक में पुरस्कृत किया गया।

केंद्रीय सचिवालय हिंदी परिषद द्वारा आयोजित 31वीं अखिल भारतीय विज्ञान एवं तकनीकी लेख प्रतियोगिता (आचार्य सत्येन बोस पुरस्कार) के अंतर्गत सैक के वैज्ञानिक श्री विवेक कुमार सिंह को प्रथम पुरस्कार, श्री आनंद पाठक, आशिष सोनी एवं हिरेन भट्ट को द्वितीय पुरस्कार तथा श्री राजेश कुमार सिंह एवं नेहा मेहरा को तृतीय पुरस्कार प्रदान किया गया। अखिल भारतीय हिंदी टंकण प्रतियोगिता में सैक की सुश्री हिरण बी. वारडे को तृतीय पुरस्कार प्रदान किया गया।

एड्रिन में संपन्न हिंदी तकनीकी संगोष्ठी के राजभाषा सत्र में श्रेष्ठ प्रस्तुति के लिए सैक के श्री मुकेश कुमार मिश्र को द्वितीय तथा श्री सोनू जैन को तृतीय पुरस्कार से सम्मानित किया गया।

GSLV
SHOE RACK

Civil Works

SAC has undertaken following civil works during the year:

1. Augmentation & extension of existing Vikram Sarabhai Space Exhibition building: The existing facility is augmented to have State- of-the- Art full air conditioned facility having 5 exhibition halls, kids space, online quiz for visitors, 3D auditorium with 70 persons sitting capacity. Its interior is planned and executed in house.

VSSE Building

2. FM Antenna container & fixture storage room near CATF building at SAC: Steel framed structure having 12 m span and 25 long high-bay with EOT crane having 10 ton capacity is constructed to provide storage for FM antenna containers and fixtures. The building in MS framed structure is constructed first time in SAC.

3. The vertical extension of building no. 30-D is carried out to accommodate additional space for holding reviews, training to officers and Seminar rooms.

Internal view of 30 D Building

4. The vertical extension of building no. 23 is carried out to accommodate Clean room of Class 10,000 for LTCC laboratory. The clean room has natural ventilation through Double glazed Ventilators for comfortable working inside clean room.

5. New Facility building for Plane Polar Nearfield Tapered Anchoic Chamber for CATF is completed and inaugurated by Chairman, ISRO on November 3, 2015.

LTCC laboratory

6. Following modification and renovation are carried out:

- MLD & MEG lab in building No.23
- Room No.4112 as Bio-optics lab-II
- Ground floor space below feed room of tapered chamber for storage area in building No.37-B
- Conference room (4363) in building No.43
- Room No. 3353 & 3354in building No. 33
- Storage shed for central store in building No.27-D
- Horizontal extension of Building No.45 for T & E lab, EMI/EMC lab and of room no 4960
- Vertical extension of building No. 44-A for CAD lab facility
- Room No. 2721 & 2722 for five axis milling machine
- Renovation of two blocks of D Type Quarters at Shastrinagar Colony, crèche and E2 Blocks at Vikram Nagar DOS housing colony

Ongoing Work

1. Civil work for Payload integration & checkout facility at 39 acres New Land at Bopal is under progress. The facility is one of its kind having a 50 m long clean room with a column free span of 40 metres and height of 21 metres which is done for the first time in ISRO and it is in final stage.

2. LTVC and HPTD facility building is under construction. During the year structural works have been substantially progressed.

3. The vertical extension of building no. 38 is in advance stage of completion.

4. The Existing Thermovac lab in building no 46 is under renovation and near completion.

Administrative and Auxiliary Activities

Finance and Accounts

During the financial year 2015-16 `720 crores expenditure and `854 crores cash flow were recorded under PAO, SAC. Details of claims handled under different categories during the year is as follows:

Sr. No.	Nature of Claims	Numbers
1	CHSS	1,32,988
2	TA /LTC /FTA	6,280
3	Foreign Bills	3,987
4	Local & Miscellaneous, Contingency /Imprest	14,329
5	CMG Bills	1,899
6	PF, Loans, Advances	1,564
7	Pre- Audit	3,381
8	Pension / Gratuity /Commutation / Family Pension / Revision of Pension / Update Allowance / Launch Campaign, D.A. Arrears /Honorarium to Consultants.	2,296

Submission of consolidated monthly Accounts, consisting of "Receipts and Payment" to Chief Controller of Accounts with reference to Demand for Grant is one of the major work as per Departmentalization of Accounts.

Various reports and returns are submitted to HQ and different Centers well within time. Considerable amount of outstanding Advance Balance is reduced with persistent efforts. Efforts have already been put to reduce both Internal as well as Resident Audit Paras and have reduced considerably.

Administration and Establishment

67 new employees, including JRFs are recruited during the year. About 98 employees superannuated and 7 employees have opted for VRS/ Resignation. Personal files of 1746 employees, 160 Apprentice and 38 JRFs/ RAs are maintained by Establishment. During the year 279 employees from various cadre are promoted to higher posts. Pension and retirement benefits to 87 employees are granted during the year. About 27 cases are processed for loans and advances.

Purchase and Stores

During the year various activities related to Procurement, disposal of unserviceable asset/scrap items, dispatch of payload and other consignments and weeding out of old records/disposal etc. are carried out. The details of activities are as follows:

1. 2900 COWAA/EGPS indents received and processed
2. About 2671 purchase orders/contract for Rs.548.44 Crores is released
3. 610 imported consignments' Customs clearance
4. 2214 consignments received in stores
5. Generated 3502 MIRVs and closed 36 discrepancies
6. Packed 138 consignments and despatched
7. 104 Tons of scrap, 565 unserviceable asset items were disposed and generated revenue of Rs.22 lakhs

Events

Following major events are organized during the year:

SAC observed fire safety week during April 14 – 20, 2015. Various events were organized towards fire safety awareness with active participation of employees, CISF personnel and their family members.

The first science workshop on NEMO-AM was organized on April 28, 2015 at SAC with an objective to excite Indian Scientific Community working in the field of atmospheric aerosols.

- Successful launch of 4 IRNSS satellites was celebrated at SAC on May 21, 2015. Shri Tapan Misra, Director SAC, Ms. Mallika Mahajan, Controller SAC, Shri Vikram Desai, Director DECU, all Deputy Directors and employees of SAC/DECU participated in the function.
- Three lectures were organized as part of Digital India Week celebration during July 6-7, 2015

On the occasion of 69th Independence Day, Shri Tapan Misra, Director SAC, unfurled the National Flag and presented Administrative Excellence Award to 8 employees

Blood Donation Camp was organized on August 8, 2015 and about 250 units of blood were collected.

- IRNSS Receiver user meet was organized with objective of providing experience sharing platform to its users on July 30, 2015

- The joint inaugural function of Tenth Satellite Communication (SATCOM -10) and first Global Navigation Satellite System (GNSS-1) was held on August 3, 2015 at Bopal campus, SAC.
- As ISRO's Satellite Instructional Television Experiment – SITE turned 40 this year, SAC and DECU celebrated its ruby anniversary on August 21, 2015. All members of team SITE joined the celebration. The event was graced by luminaries like Prof. Yashpal, Prof. E V Chitnis, Dr. P v Krishnamoorthy, Shri Pramod Kale, Shri Kiran Karnik, Shri K Narayanan, Shri B S Bhatia, Shri Leo Lasarado, Shri S K Singh and Shri G C Jain.

- World Space Week was celebrated at VSSE during October 4-10, 2015
- Successful operation of GSAT-15 was celebrated on November 11, 2015
- Cancer detection camp was organized for female employees of SAC during December 16-17, 2015 at Vikramnagar Dispensary
- During DOS-ISRO Inter Centre Sports Meet – 2015, SAC achieved third position and won overall championship trophy
- Tree plantation drive was launched on December 22, 2015 and till March 31, 2016 more than 350 trees were planted in SAC campus
- 67th Republic Day was celebrated in SAC campus, Shri Tapan Misra, Director, SAC unfurled the National Flag. The meritorious students of SAC and DECU community in X and XII board exams were felicitated by Director, SAC.
- SAC actively participated in "Make in India" week during February 13-18, 2016
- SAC Sports Council celebrated Annual Day on February 20, 2016 in which cultural events were performed by employees
- During February, 2016 H1N1 prevention camp was organized for all current and retired employees of SAC as well as their dependents
- International Women's Day was celebrated with great enthusiasm on March 8, 2016
- National Safety Week was observed during March 4-10, 2016 in which various activities and competitions like safety poster painting, safety essay writing, safety slogan writing, safety movie screening and fire mock drills were organized at SAC and Bopal campus.

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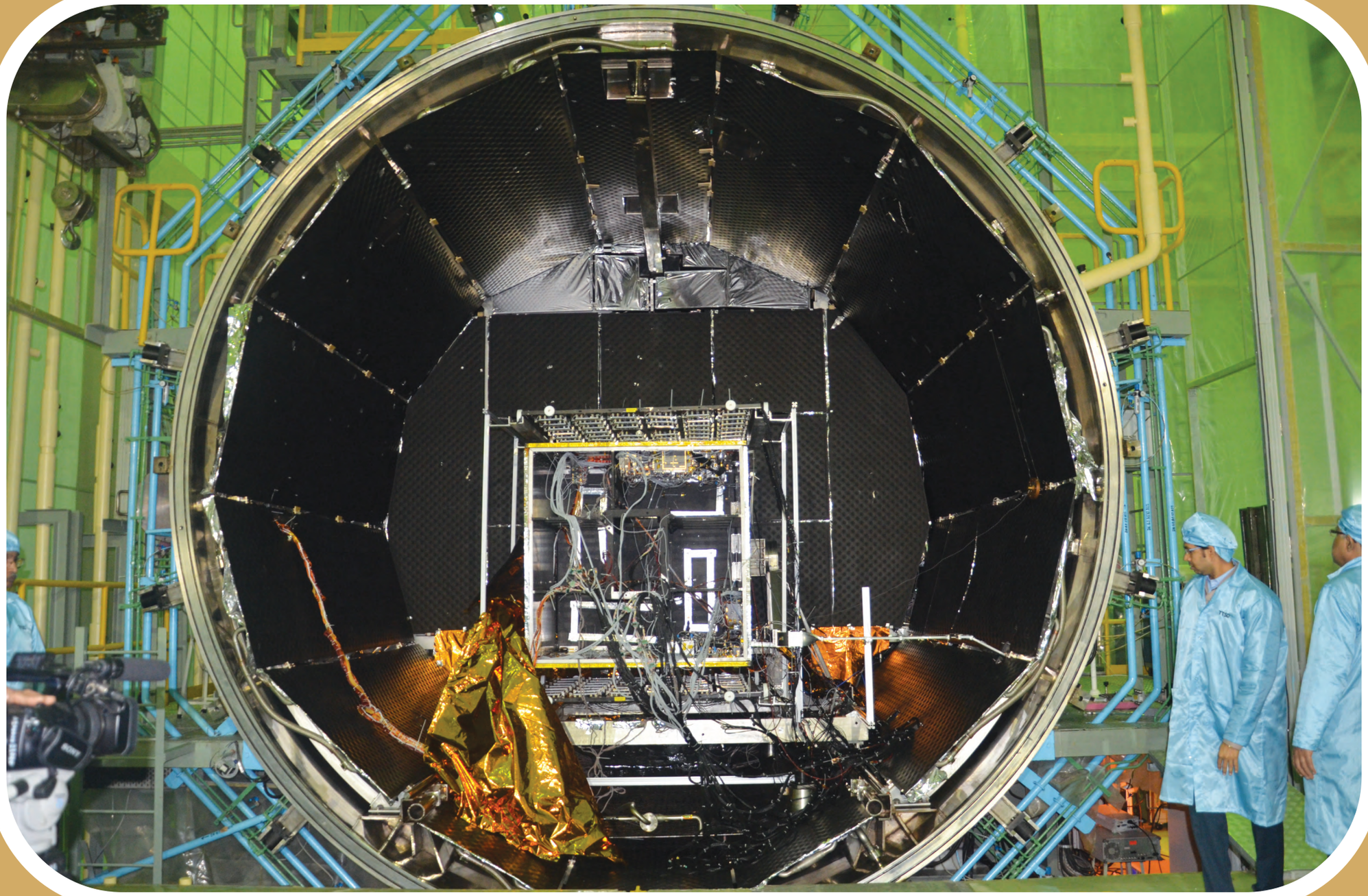

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